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SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS 1970-1971, ANNUAL ISSUE (2ND)

Gaylord V. Skogerboe, et al

Colorado State University
Fort Collins, Colorado

June 1973

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Selected Irrigation Return Flow Quality Abstracts 1970-1971

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G~~aylord~~ V. Skogerboe, W~~ynn~~ R. Walker,
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Research related to the quality of irrigation return flow is being conducted at numerous institutions throughout the western United States. Related work is also underway at other institutions in the United States, as well as other portions of the world. Approximately 100 sources of material have been searched for articles pertinent to the National Irrigation Return Flow Research and Development Program. These articles describe water quality problems resulting from irrigated agriculture, potential technological solutions for controlling return flows, recent research pertinent to return flow investigations, and literature associated with institutional constraints in irrigation return flow quality control.

This second annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS ~~covers publications printed in 1970 and 1971. This report was submitted in fulfillment of Grant Number R-800426 under the sponsorship of the Office of Research and Monitoring, Environmental Protection Agency.~~ Contains approximately 450 abstracts of documents published in 1970 and 1971. Author and subject indexes are included. (EPA)

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June 1973

SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS 1970-1971

Second Annual Issue

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ABSTRACT

Research related to the quality of irrigation return flow is being conducted at numerous institutions throughout the western United States. Related work is also underway at other institutions in the United States, as well as other portions of the world. Approximately 100 sources of material have been searched for articles pertinent to the National Irrigation Return Flow Research and Development Program. These articles describe water quality problems resulting from irrigated agriculture, potential technological solutions for controlling return flows, recent research pertinent to return flow investigations, and literature associated with institutional constraints in irrigation return flow quality control.

The first annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS covered publications printed in 1968 and 1969, while the second annual issue lists publications printed in 1970 and 1971. This report was submitted in fulfillment of Grant Number R-800426 under the sponsorship of the Office of Research and Monitoring, Environmental Protection Agency.

Key Words: Fertilizers, Irrigated Land, Irrigated Systems, Irrigation Water, Nitrates, Phosphates, Return Flow, Salinity, Water Pollution Effects, Water Pollution Sources, Water Quality Control.

FOREWORD

The second annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS has been compiled from approximately 100 sources of material covering calendar years 1970 and 1971. This compilation has attempted to include technological and institutional articles that would be pertinent to action programs regarding the control of water quality degradation resulting from irrigated agriculture.

The state-of-the-art report, "Characteristics and Pollution Problems of Irrigation Return Flow" prepared by the Utah State University Foundation contains a bibliography of articles pertinent to Irrigation Return Flow Quality Control. The references in this bibliography include articles and reports prior to 1968. The first annual issue of SELECTED IRRIGATION RETURN FLOW QUALITY ABSTRACTS listed publications appearing in calendar years 1968 and 1969.

The second annual issue contains approximately 450 abstracts of documents published during calendar years 1970 and 1971. The abstracts have been placed into sections according to the category and subgroup classifications used by the Water Resources Scientific Information Center (WRSIC) as published in the report, "Water Resources Thesaurus." The abstracts have been forwarded to WRSIC for inclusion in their bi-monthly publication, "Selected Water Resources Abstracts."

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TABLE OF CONTENTS

Section		Page
I	NATURE OF WATER - AQUEOUS SOLUTIONS AND SUSPENSIONS (Group 01B)	1
II	WATER CYCLE - GENERAL (Group 02A)	3
III	WATER CYCLE - SNOW, ICE AND FROST (Group 02C)	5
IV	WATER CYCLE - EVAPORATION AND TRANSPIRATION (Group 02D)	7
V	WATER CYCLE - STREAMFLOW AND RUNOFF (Group 02E)	17
VI	WATER CYCLE - GROUNDWATER (Group 02F)	23
VII	WATER CYCLE - WATER IN SOILS (Group 02G)	43
VIII	WATER CYCLE - LAKES (Group 02H)	77
IX	WATER CYCLE - WATER IN PLANTS (Group 02I)	79
X	WATER CYCLE - EROSION AND SEDIMENTATION (Group 02J)	87
XI	WATER CYCLE - CHEMICAL PROCESSES (Group 02K)	89
XII	WATER SUPPLY AUGMENTATION AND CONSERVATION - SALINE WATER CONVERSION (Group 03A)	105
XIII	WATER SUPPLY AUGMENTATION AND CONSERVATION - WATER YIELD IMPROVEMENT (Group 03B)	107
XIV	WATER SUPPLY AUGMENTATION AND CONSERVATION - USE OF WATER IN IMPAIRED QUALITY (Group 03C)	109
XV	WATER SUPPLY AUGMENTATION AND CONSERVATION - CONSERVATION IN AGRICULTURE (Group 03F)	117
XVI	WATER QUANTITY MANAGEMENT AND CONTROL - CONTROL OF WATER ON THE SURFACE (Group 04A)	141
XVII	WATER QUANTITY MANAGEMENT AND CONTROL - GROUNDWATER MANAGEMENT (Group 04B)	157
XVIII	WATER QUANTITY MANAGEMENT AND CONTROL - EFFECTS ON WATER OF MAN'S NON-WATER ACTIVITIES (Group 04C)	165
XIX	WATER QUANTITY MANAGEMENT AND CONTROL - WATERSHED PROTECTION (Group 04D)	167
XX	WATER QUALITY MANAGEMENT AND PROTECTION - IDENTIFICATION OF POLLUTANTS (Group 05A)	169
XXI	WATER QUALITY MANAGEMENT AND PROTECTION - SOURCES OF POLLUTION (Group 05B)	175
XXII	WATER QUALITY MANAGEMENT AND PROTECTION - EFFECTS OF POLLUTION (Group 05C)	195
XXIII	WATER QUALITY MANAGEMENT AND PROTECTION - WASTE TREATMENT PROCESSES (Group 05D)	201
XXIV	WATER QUALITY MANAGEMENT AND PROTECTION - ULTIMATE DISPOSAL OF WASTES (Group 05E)	209

Preceding page blank

TABLE OF CONTENTS (Cont'd)

Section		Page
XXV	WATER QUALITY MANAGEMENT AND PROTECTION - WATER TREATMENT AND QUALITY ALTERATION (Group 05F)	211
XXVI	WATER QUALITY MANAGEMENT AND PROTECTION - WATER QUALITY CONTROL (Group 05G)	213
XXVII	WATER RESOURCES PLANNING - TECHNIQUES OF PLANNING (Group 06A)	219
XXVIII	WATER RESOURCES PLANNING - EVALUATION PROCESS (Group 06B)	223
XXIX	WATER RESOURCES PLANNING - COST ALLOCATION, COST SHARING, PRICING/REPAYMENT (Group 06C)	225
XXX	WATER RESOURCES PLANNING - WATER DEMAND (Group 06D)	227
XXXI	WATER RESOURCES PLANNING - WATER LAW AND INSTITUTIONS (Group 06E)	229
XXXII	RESOURCES DATA - DATA ACQUISITION (Group 07B)	231
XXXIII	ENGINEERING WORKS - STRUCTURES (Group 08A)	235
XXXIV	ENGINEERING WORKS - HYDRAULICS (Group 08B)	237
XXXV	ENGINEERING WORKS - HYDRAULIC MACHINERY (Group 08C)	239
XXXVI	ENGINEERING WORKS - SOIL MECHANICS (Group 08D)	241
XXXVII	ENGINEERING WORKS - FISHERIES ENGINEERING (Group 08I)	243
XXXVIII	AUTHOR INDEX	245
XXXIX	SUBJECT INDEX	256
XXXX	ACKNOWLEDGMENTS	285

Section I

NATURE OF WATER

AQUEOUS SOLUTIONS AND SUSPENSIONS (Group 01B)

70-71:01B-001
A RAPID METHOD OF MEASUREMENT OF DIFFUSSION COEFFICIENTS IN AQUEOUS SOLUTIONS,
Phillips, R. E., and Ellis, J. H.
Kentucky University, Lexington.
Soil Science, Vol. 110, No. 6, p 421-425, December 1970. 1 fig, 1 tab, 9 ref.

Descriptors: *Diffusion, *Ion transport, *Aqueous solutions, Soil moisture, Water chemistry.
Identifiers: *Diffusion measurement, Capillary tube.

A capillary-tube method of measuring diffusion coefficients of compounds in aqueous solution is described whereby diffusion coefficients of ions and salts important in soils which are not usually available in the literature can be measured in solution with a mean coefficient of variation of approximately 5.1 percent. The coefficient of variation of diffusion coefficient measurements is larger than with more refined methods; however, the capillary-tube method is simple enough that it can be measured in any research laboratory and requires no specialized instrumentation other than that found in most soil research laboratories.

70-71:01B-002
SALINITY AND WATER USE,
Talsma, T., and Philip, J. R.
The MacMillan Press, London, England. 1971. 296 p, 2 append.

Descriptors: *Salinity, *Biology, *Social aspects, Water quality, Soil chemistry, Water chemistry, Economics, Soil physics.

The second National Symposium on Hydrology, organized by the Australian Academy of Science, offered an up-tp-date review of the scientific, and to some extent, social backgrounds of natural and man-made salinity. The conference was held on November 2-4, 1971, at Canberra, Australia. The papers ranged widely, from the geochemistry, soil physics, hydraulics and biology of salinity, to legal and administrative aspects. These authoritative reviews by specialists in many fields constitute an important reference work for Australia and other countries with similar problems. Contained are the proceedings of the symposium which included 17 papers under the general headings of: Nature and Origin of Salinity, Chemistry and Chemical Processes, Physical Processes, Biology and Salinity, Social Considerations and Perspectives. Also, the references and list of contributors make it a good source of information.

70-71:01B-003
THERMODYNAMICS OF SALINE WATER,
Lane, J. E., and Mansfield, W. W.
Commonwealth Scientific and Industrial Research Organization, Fishermen's Bend, Victoria, Australia, Division of Applied Chemistry.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 43-60. 2 fig, 18 ref.

Descriptors: *Water quality, *Thermodynamics, *Saline water systems, Aqueous solutions, Salinity, Heat, Energy transfer, Temperature.

The thermodynamic state of a saline solution is completely specified by the temperature, pressure and chemical potentials of the components that are present. The chemical potential can be defined rigorously in mathematical terms but in this form often provides difficulty in conception. In order to overcome this difficulty for solutions, it is useful to relate the chemical potential to some ideal reference solution; the deviation between real and ideal solution is formalized in terms of an activity coefficient, and sometimes in the case of a solvent by an osmotic coefficient. The activity coefficients can be obtained from experiment, and are well tabulated. Changes in the chemical potentials of the components of a saline solution due to variations in temperature, pressure, environment or the external field can be obtained by the use of very simple expressions; any additional information required is measurable. These relationships are applied to desalination by distillation, by freezing and by reverse osmosis, to Donnan membrane equilibria, to the resting potential of a nerve fibre, and to surface effects in a porous solid.

70-71:01B-004
GROUNDWATER PROBLEMS OF THE INTERACTION OF SALINE AND FRESH WATER,
Wooding, R. A.
Commonwealth Scientific and Industrial Research Organization, Canberra, Australia, Division of Environmental Mechanics.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 125-139. 55 ref.

Descriptors: *Mathematical model, *Porous media, *Saline water systems, Saline water intrusion, Saline water-freshwater interfaces, Mixing, Saline water barriers.

This paper reviews selected hydrodynamical aspects relevant to flow of saline groundwater in a non-reacting medium. Topics covered include macroscopic scales and dimensionless parameters, conditions for stable flow, problems of stably-stratified flows, stable and unstable mixing layers.

70-71:01B-005
THE TRANSPORT OF SALT IN RIVERS AND ESTUARIES,
Wood, I. R.
New South Wales University, Manly Vale, Australia, Water Research Laboratory.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 141-157. 8 fig, 30 ref.

Descriptors: *Water chemistry, *Salts, Saline water, Salinity, Water quality, Saltation, Bedload, Estuaries.

In order to follow the transport of salt in rivers, estuaries and lakes, it is not only necessary to be able to analyse the flows in these systems but also to understand the diffusion processes in these flows. This paper reviews the progress in understanding these processes and in analysing cases of engineering importance. The situations discussed are: 1. Flows where the variations in salt concentration are so small that the effect on the flow properties of the system may be neglected. This is called a well mixed flow and in this case the analysis is based on Taylor's classic papers on dispersion. 2. Flows where the salt concentration gradients acted on by the gravitational field cause internal flows which dominate the transport of salt. In this case the flow may be analysed as two distinct layers. Where the above approximations are not reasonable the flow is called a partially mixed flow and for simple cases, the analysis used is the same as that for a well mixed flow but with a greatly increased dispersion coefficient.

Section II

WATER CYCLE

GENERAL (Group 02A)

70-71:02A-001
PREDICTING SURFACE RUNOFF FROM AGRICULTURAL WATERSHEDS,
Melvin, S. W., Johnson, H. P., and Beer, C. E.
Iowa State University, Ames, Dept of Agricultural Engineering.
American Society of Agricultural Engineers Transactions, Vol. 14, No. 3, p 505-510, May-June 1971. 4 fig, 4 tab, 11 ref.

Descriptors: *Runoff forecasting, *Computer programs, Surface runoff, Infiltration, Agricultural watersheds, Water yield, Excess water (Soils), Precipitation excess, Small watersheds, Routing.

A simple infiltration model predicts runoff from mixed cover agricultural watersheds in a deep loess soil region. The surface runoff prediction method is consistent between watershed basins in the study region. The relationship between predicted and observed runoff varied with time during the growing season. Little improvement in runoff prediction could be accounted for by revised multiple regression equations. Runoff predictions are made using FORTRAN computer program. Input data required for each watershed runoff prediction included: (a) storm identification, watershed, date; (b) areal distribution of the three predominate crop cover conditions; (c) precipitation recorded during each of the seven days preceding the storm; and table of time cumulative precipitation values representing the storm.

70-71:02A-002
A STOCHASTIC MODEL OF LONGITUDINAL DIFFUSION IN POROUS MEDIA,
Todorovic, P.
Colorado State University, Fort Collins.
Water Resources Research, Vol. 6, No. 1, p 211-222, February 1970. 12 p, 11 fig, 2 tab, 3 ref.

Descriptors: *Statistical models, *Diffusion, *Stochastic processes, *Groundwater movement, *Porous media, Model studies, Mathematical models, Statistical methods, Diffusivity, Hydraulic models, Dispersion, Tracking techniques, Tagging, Tracers.
Identifiers: Longitudinal dispersion.

A set of tagged particles carried along by a fluid flow through a porous media is subject to random dispersion. The total distance from the origin, in the direction of the main flow traveled by a tagged particle, is a stochastic process. To use Lagrangian description of the dispersion, the distribution function of the traveled distance for every time must be determined. This distribution is not Gaussian and depends on two parameters which in turn depend on hydraulic conditions. To apply Eulerian description, the distribution function of time a tagged particle to travel a given distance x is derived. This distribution is not Guassian either, and depends on the same two parameters. The sum of these two distributions is always one. This identity represents the relationship between Lagrangian and Eulerian descriptions. According to experimental results, the theoretical distributions agree reasonably well with observed distribtuions.

70-71:02A-003
A CONCEPTUAL MODEL OF THE GROUNDWATER REGIME AND THE HYDROGEOLOGIC ENVIRONMENT,
Toth, J.
Research Council of Alberta, Edmonton.
Journal of Hydrology, Vol. 10, No. 2, p 164-176, February 1970. 13 p, 1 fig, 9 ref.

Descriptors: *Hydrogeology, *Model studies, *Equations, *Mathematical models, Aquifers, Groundwater movement, Hydrologic budget, Regime, Mathematical studies, Discharge (Water), Climates, Geology, Water chemistry.
Identifiers: Hydrogeologic environment, Groundwater regime.

A conceptual model for the description, explanation, prediction, and control of hydrogeologic conditions is composed of two systems of physical and chemical parameters: the Hydrogeologic Environment, and the Groundwater Regime. The three components of the environment, each comprising a great number of parameters, are topography, geology, and climate. The necessary and sufficient parameters of the groundwater regime are: (1) amount of water, (2) geometric distribution of water movement, (3) volume or velocity of the flow, (4) chemical composition, (5) temperature, and (6) regime variance. The environment and regime are related quantitatively and each regime parameter can be expressed mathematically as a function of the environmental components. This allows the evaluation of the groundwater regime if the environmental conditions are known, as well as inferences concerning the aquifer from known properties of the regime. To date few parameters have been evaluated exactly, and mostly conceptual equations are presented.

70-71:02A-004
SALINITY AND THE HYDROLOGIC CYCLE,
Holmes, J. W.
Flinders University, South Australia. School of Physical Sciences.
Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971. Canberra, Australia, p 25-40. 6 fig, 8 tab, 21 ref.

Descriptors: *Water resources, *Hydrology, *Hydrologic cycle, *Surface waters, Water quality, Salinity, Streamflow, Runoff, Erosion, Sedimentation, Water chemistry, Hydrologic systems.

The hydrologic cycle, as a concept to allow orderly description of the ways in which precipitation on the land surface is partitioned between evaporation, run-off and other lesser consumption, usually exists in a natural steady state. If not, then at least, natural perturbations have a time scale of the order of thousands of years. The hydrologic cycle transports salts as the solute load of the various water discharges. The salt cycle also usually exists in a steady state. Irrigation, and other less drastic changes in land utilization, which affect the components of the water budget, perturb the hydrologic and salt cycle with a time scale that may be of the order of tens of years. Deterioration of water quality in rivers and secondary salinization of soils are two major consequences of a disruption of the natural regime, initiated by the needs of civilization.

Section III

WATER CYCLE

SNOW, ICE, AND FROST (Group 02C)

70-71:02C-001
FROST AND COLD PROTECTION BY SPRINKLERS: NEW ASSESSMENT,
Gray, A. S.
Rain Bird Sprinkler Manufacturing Company, Glenora, California.
World Irrigation, Vol. 20, No. 2, p 12-13, March 1970. 1 fig.
(See 70-71:04A-021)

Section IV

WATER CYCLE

EVAPORATION AND TRANSPIRATION (Group 02D)

70-71:02D-001
ADVECTION AND EVAPOTRANSPIRATION OF WIDE-ROW SORGHUM IN THE CENTRAL GREAT PLAINS.
Hanks, R. J., Allen, L. H., and Gardner, H. R.
Utah State University, Logan, Department of Soils and Meteorology.
Agronomy Journal, Vol. 63, No. 4, p 520-527, 1971. 4 tab, 8 fig, 18 ref.

Descriptors: *Evapotranspiration, *Advection, *Grain sorghum, Temperature.
Identifiers: Central Great Plains, Wide-row sorghum, Climate.

This study was conducted to evaluate the importance of advection as a source of energy for evapotranspiration from grain sorghum planted in 1-m rows with both irrigated and dryland conditions. Detailed measurements of temperature, water vapor content, and wind speed were made within and above the canopy at various times and positions within the field during August 1967. Evapotranspiration was also measured by soil moisture sampling. Three types of advection were observed. Within canopy advection resulted from the large amount of exposed dry soil between rows, which caused soil temperature between the rows to be as much as 20 C higher than plant temperature. About 64% of the energy used to heat up the soil was used for transpiration in the irrigated plot, whereas only about 21% of the energy was used for transpiration in the dryland plot. Border advection, manifested by horizontal temperature and water vapor gradients, occurred over most of the plot irrigated but was most evident from 0 to 40 m from the upwind edge. This type of advection yielded sufficient energy to account for about 30% of the energy used for evapotranspiration from the irrigated plot. Large scale advection, manifested by temperature inversions, was found to occur during the night and probably yielded very little energy used for evapotranspiration.

70-71:02D-002
EFFECT OF WATER-TABLE LEVELS ON EVAPOTRANSPIRATION AND CROP YIELD,
Williamson, R. E., and Carreker, John R.
Agricultural Research Service, Raleigh, North Carolina, Soil and Water Division.
American Society Agricultural Engineers Transactions, Vol. 13, No. 2, p 168-170, March-April 1970. 3 p, 4 fig, 5 tab.

Descriptors: *Evapotranspiration, *Model studies, Rainfall, Soils, Water table, Crops.
Identifiers: *Water-table levels, *Crop yield, Soil tanks.

Crops were grown in soil tanks with different depths to the water table in 1959 to 1964, inclusive. Six tanks were without shelters and subjected to rainfall, and 48 tanks were protected from rain by rain-controlled, electrically operated shelters. Surface soils used in these tanks were Norfolk fine sandy loam in the non-sheltered tanks, fine sandy loam in 20 sheltered tanks, and Bayboro loam in 28 sheltered tanks. No attempt was made to reconstruct the soil profiles. These soils were adjusted initially to pH 6.0 with dolomitic limestone. Fertilizer and lime were mixed into the top 6 in. each year. Salt content was monitored and the sheltered tanks were leached as necessary to prevent a buildup of salts. Water-table levels were established 2 to 3 weeks after crops were planted. The depths to water were 6, 18, and 30 in. in the non-sheltered tanks and 6, 12, 18, 24, and 30 in. in the sheltered tanks 3 feet deep. Additional levels of 36 and 40 in. were maintained in sheltered tanks 4 feet deep. Daily rates of evapotranspiration in the sheltered tanks generally were slightly higher for the 12-in. depth to water table tnan for the 6-in. depth. The rate then tended to decline as depth increased with most crops. Tables and curves relating rainfall, water tables, soils, and crops to evapotranspiration are presented.

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70-71:02D-003
EVAPOTRANSPIRATION AND ENERGY BALANCES OF FOREST AND FIELD,
Tajchman, S. J.
Aberdeen University (Scotland), Department of Botany.
Water Resources Research, Vol. 7, No. 3, p 511-523, June 1971, 13 p, 2 fig, 7 tab, 48 ref.

Descriptors: *Evapotranspiration, *Crops, *Forests, *Energy budget, *Heat balance, Convection, Heat transfer, Potatoes, Solar radiation, Microclimatology, Micrometeorology, Advection, Heat flow, Vegetation effects.

The energy and water balance components of a 70-year-old Norway spruce forest, a 2-year-old alfalfa field, and a potato field near Munich, Germany, were computed for the period May-October 1965 by using hourly averages of meteorologic parameters. Turbulent diffusion and energy budget methods were used to determine evapotranspiration and convective exchange. The two methods yielded satisfactory agreement for the low crops but not for the forest. The mean seasonal albedo values for the potatoes and crops but not for the forest. The mean seasonal albedo values for the potatoes and the alfalfa were 0.18 and 0.22, respectively. The albedo of the forest was obtained for 1 day and averaged 0.05. The shortwave incoming radiation over the forest was 12% less than that over the fields. The net shortwave radiation over the forest was 2 and 7% greater than that over the potatoes and the alfalfa, respectively, whereas the long wave emission from the forest was 22 and 15% less than that from the potatoes and the alfalfa, respectively. The total net radiation over the forest was 20% greater than that over the alfalfa and 16% greater than that over the potatoes. Sensible heat flux from the forest was 2.6 and 1.6 times greater than that from the alfalfa and the potatoes, respectively. Evapotranspiration from the forest was 4% less than that from the alfalfa but 14% greater than that from the potatoes. The exchange coefficient at the top of the trees was about 100 times as large as that at the top of the crops.

70-71:02D-004
EFFECTS OF KAOLINITE AS A REFLECTIVE ANTITRANSPIRANT ON LEAF TEMPERATURE, TRANSPIRATION, PHOTOSYNTHESIS, AND WATER-USE EFFICIENCY,
Abou-Khaled, Antoine, Hagen, Robert M., and Davenport, David C.
California University, Davis,
Water Resources Research, Vol. 6, No. 1, p 280-289, February 1970. 10 p, 11 fig, 32 ref.

Descriptors: *Transpiration control, *Evapotranspiration control, *Kaolinite, Consumptive use, Water conservation, Light intensity, Soil-water-plant relationships.
Identifiers: Antitranspirants.

Transpiration and photosynthesis are influenced by the optical properties of leaves. Application of a uniform white coating of kaolinite to the upper leaf surface produced significant changes in the spectral curves (reflectivity, transmissivity, and absorptivity) of Valencia orange leaves. Photosynthetic light response curves of leaves of orange, lemon, rubber plant (all hypostomatous), and bean (amphibiostomatous) were modified by the reflective material, which at low light intensities decreased photosynthetic rates and increased light saturation levels. The white coating cooled the leaves 3-4 deg C and reduced transpiration 22-28% under conditions of high light intensity, warm air, low relative humidity, and low wind velocity. However, the rubber plant under the same conditions showed a smaller reduction in transpiration (less than 10%), indicating effective self-regulation of its water loss. These experiments demonstrated that water-use efficiency of leaves can be improved, particularly under high light intensities.

70-71:02D-005
EVAPORATION OF BRINE: A FIELD STUDY ON THE BONNEVILLE SALT FLATS, UTAH,
Turk, L. J.

Texas University, Austin.
Water Resources Research, Vol. 6, No. 4, p 1209-1215, August 1970. 7 p, 4 fig, 4 tab, 18 ref.

Descriptors: *Evaporation, *Brines, Utah, Salinity, Water vapor, Solar radiation, Vapor pressure, Hydrologic budget, Water balance, Evaporation pans.
Identifiers: Bonneville Salt Flats.

Evaporation rates were determined for seven brines of average specific gravities from 1.207 to 1.333. Evaporation of the brines ranged from 70% to 9.5%, respectively, of the freshwater evaporation rate. The field data agree exceptionally well with differential vapor pressures over Great Salt Lake brine. Water occasionally condenses on the heavier brines because of an inverted vapor pressure gradient.

70-71:02D-006
A GENERALIZED COMPUTER PROGRAM FOR THE SOLUTION OF THE PENMAN EQUATION FOR EVAPOTRANSPIRATION,
Chidley, Thomas R. E., and Pike, John G.
Aston University, Birmingham (England).
Journal of Hydrology, Vol. 10, No. 1, p 75-89, January 1970. 15 p, 1 tab, 6 ref, 5 append.

Descriptors: *Evapotranspiration, *Consumptive use, *Solutions, *Computer programs, *Computer programming, Meteorological data, Hydrology.
Identifiers: *Penman equation, Potential evaporation, ALGOL, Water budget.

A generalized computer program that has a wide application with regard to location and variety of input data is given for solving the Penman equation for evapotranspiration. The form of output is designed to provide an immediate record of potential evaporation rates and a summary of the meteorological data used. The main elements of the Penman equation are in self-contained blocks, enabling changes to be made in some of the sections of the program to allow for more advanced methods. Possible lines of development of this program are: (1) More sophisticated procedures for computing the saturation vapor pressure and the slope of the saturation vapor pressure for differing conditions. The formulas used in the program apply only to conditions over water at normal pressure. (2) From the point where the program begins to substitute the time-averaged data into the Penman equation, the whole program, excluding output, could be written as an ALGOL procedure, enabling the formula to be more readily incorporated within the body of other programs, such as water budget problems. (3) The aerodynamic term could be modified to include a wind term based on wind profile theory incorporating surface roughness to give more reliable estimates for short time periods.

70-71:02D-007
EVAPOTRANSPIRATION MEASUREMENT BY CHLORIDE TRANSLOCATION,
Dylla, A. S., and Stuart, D. M.
Agricultural Research Service, Reno, Nevada, Soil and Water Conservation Research Division.
Journal of Hydrology, Vol. 10, No. 2, p 185-192, February 1970. 8 p, 2 fig, 3 tab, 7 ref.

Descriptors: *Evapotranspiration, *Soil chemistry, *Root zone, *Mass transfer, *Soil water movement, Chlorides, Saline water systems, Leaching, Soil-water-plant relationships, Water chemistry, Solutes.
Identifiers: Chloride translocation.

Profiles in evapotranspiration tanks were sampled at the start and end of the 1968 growing season to determine chloride ion translocation into the top 90 cm of the soil by which seasonal evapotranspiration was estimated. Coefficients of variation between profile totals ranged from 0.11 to 0.21 for the profiles sampled in April and from 0.39 to 0.45 for profiles sampled in October. The lower variation in April is attributed to the pre-season leaching. The greatest increase in chlorides in the vegetated tanks occurred in the top 15 cm; however, there was significant increase in all sample increments down to 60 cm, which is about the depth of the meadow grass rooting. Variability of total chlorides in adjacent soil profiles of vegetated surfaces makes the method of determining seasonal or long-term evapotranspiration from chloride translocation only a rough estimate. To obtain valid mean chloride profiles from which good evapotranspiration estimates could be expected would require very extensive soil sampling and nonchanging groundwater quality below the root zone during the measuring interval or season.

70-71:02D-008
WATER BALANCE OF A SEED ONION FIELD,
Goltz, S. M., Tanner, C. B., Millar, A. A., and Lang, A. R. G.
Wisconsin University, Madison, Department of Soil Science.
In: Actual Evapotranspiration as Determined from Soil-Water and Canopy Characteristics and Potential Evapotranspiration, Progress Report p I1-I14, August 1971. 4 fig, 4 tab, 8 ref.

Descriptors: *Water balance, *Onions, *Crop response, *Seeds, *Experimental forms, Environmental effects, Stomata, Evapotranspiration, Evaporation, Winds, Soil moisture, Temperature, Projects, Evaluation, Soil-water-plant relationships, Horticultural crops.
Identifiers: *Research projects, *Seed onion field.

Transpiration, evaporation, and drainage from a sparsely populated onion field were measured separately by a method which should be applicable to many row crops. Transpiration computed from measured evapotranspiration, potential evaporation, and stomatal resistances agreed well with values calculated independently from measured stomatal resistance, air vapor pressure, plant-temperature and wind. Transpiration was only about 20% of total evapotranspiration. When the population was increased threefold to near maximum commercial density, evapotranspiration increased only about 15% because as transpiration increased, evaporation decreased. The portion of transpiration accounted for by each plant part was 3% for umbels, 42% for leaves and 55% for scapes. Drainage from the sandy soil exceeded evapotranspiration.

70-71:02D-009
A RESISTANCE MODEL OF EVAPORATION DURING SPRINKLING,
Seginer, Ido.
Technion-Israel Institute of Technology, Haifa.
Agricultural Meteorology, Vol. 7, No. 6, p 487-497, 1970. 8 fig, 1 tab, 2 ref.

Descriptors: *Water loss, *Sprinkler irrigation, Mathematical model, Energy balance, Irrigation.

Identifiers: Balance, Energy, Equation, Evaporation, Model, Resistance, Sprinkling.

A previous resistance model of sprinkler evaporation is expanded by considering 2 energy balance equations: one for the drops and another for the air layer where the evaporation takes place. To solve for the various fluxes, only the boundary conditions and the resistance of the system must be given. A comparison of calculations with experimental results, indicated good agreement for the limiting case of a wet surface with no drops in the air. The model predicts small spray evaporation under normal operating conditions. The effects of water temperature, fitness of spray and application rate on the evaporation losses may be significant, if the variation of any of these parameters is within wide limits.

70-71:02D-010
AN EXPERIMENTALLY DERIVED MODEL FOR ACTUAL EVAPOTRANSPIRATION,
Eagleman, J. R.
Kansas University, Lawrence, Dept of Geography and Meteorology.
Agricultural Meteorology, Vol. 8, No. 4/5, p 385-394, 1971. Illus. 2 tab, 5 fig, 11 ref.

Descriptors: *Potential evapotranspiration, *Soil moisture, Statistical model, Environmental effects, Water loss.

Identifiers: Model, Moisture, Plant, Soil, Transpiration.

Experimental data from several different climatic regions were used to develop a statistical model for actual water loss rates from land surfaces. The actual evapotranspiration rate was considered to be influenced by the amount of available water in the soil and by meteorological and plant conditions which determine the potential evapotranspiration rate. Experimental measurements of these 3 variables from various environmental conditions were combined into a single model expressing the composite relationship. Actual evapotranspiration rates were calculated from this relationship using the variables soil moisture and potential evapotranspiration. Initial testing showed that the model gave satisfactory results when used for estimating moisture changes in the soil.

70-71:02D-011
FIELD MEASUREMENT OF PAN EVAPORATION,
Sims, James R., and Jackson, G. D.
Montana Agricultural Experiment Station, Bozeman.
Agronomy Journal, Vol. 53, No. 2, p 339-340, 1971. Illus. 1 tab, 2 fig, 3 ref.

Descriptors: *Pan evaporation, Instrumentation, Evaporimeter.

Identifiers: *Evaporation, Field, Measurement, Pan.

An inexpensive method for measuring pan evaporation at off-station sites was developed. Evaporation measured by the new method was significantly correlated (1% level) with evaporation measured with a standard USA Weather Bureau class A evaporation pan.

70-71:02D-012
MICROCLIMATE MODIFICATION BY MANIPULATION OF NET RADIATION,
Martsolf, J. D., and Decker, W. L.
Missouri University, Columbia, Dept of Atmospheric Science.
Agricultural Meteorology, Vol. 7, No. 3, p 197-216, 1970. 3 tab, 10 fig, 12 ref.

Descriptors: Radiation, Evaporation, Evapotranspiration, Atmometer, Soybean, Evaporation control.
Identifiers: Net radiation, Microclimate modification, Vegetative canopy, Louvers, Radiometer.

An argument assuming the shade to be flush with the canopy and based on the alteration of albedo, predicts the reduction in net radiation with increasing shade, both above and below the shade, to be a linear function of the horizontal area shaded. Observations of the effect of a louvered shade on net radiation by transversing net radiometers beneath the shade, on evaporation by atmometer sampling, on evapotranspiration by a neutron scattering technique and on leaf temperature extremes by thermocouples, were made over and within a soybean canopy. The reduction in net radiation was observed to be directly proportional to the horizontal area shaded. For the case in which two-thirds of the area was shaded, the reduction in atmometer evaporation was over three times as large as the reduction in evapotranspiration and the moderation of average maximum and minimum leaf temperatures was on the order of 5 deg F. Graphical representations of the variations of net radiation with time for the geometrically repeated patterns beneath the louvers suggest a modification of stomatal activity which might explain the great difference between the effect of shade on evaporation and evapotranspiration.

70-71:02D-013
EFFECTS OF ROW SPACING ON EVAPOTRANSPIRATION AND YIELDS OF CORN IN A SEMIARID ENVIRONMENT,
Fairbourn, M. L., Kemper, W. D., and Gardner, H. R.
Agricultural Research Service, Fort Collins, Colorado.
Agronomy Journal, Vol. 62, No. 6, p 795-797, 1970. 3 tab, 3 fig, 10 ref.

Descriptors: *Evapotranspiration, *Yields, Corn, Planting management.
Identifiers: *Row spacing, *Water use efficiency, Microwatershed systems, Semiarid environment, Corn (Zea mays L.).

A study was made in 1967 and 1968 on a Nunn clay loam soil to determine the effects of row spacing on evapotranspiration (ET) and yields of corn (Zea mays L.) in a semiarid environment. Double rows 0.3 m apart flanked on each side by spaces 1.8 m wide as used in the microwatershed system were compared with single rows in spacings of 0.9, 1.2, and 1.8 m. ET and yields of the double rows and the single rows of 0.9 and 1.2 m spacings were very similar. These results indicate an important degree of freedom is allowed in planning management systems such as microwatersheds to increase water use efficiency.

70-71:02D-014
EVAPOTRANSPIRATION FROM A SNAP BEAN CROP,
Black, T. A., Tanner, C. B., and Gardner, W. R.
British Columbia University, Vancouver, Canada, Dept of Soil Science.
Agronomy Journal, Vol. 62, No. 1, p 66-69, 1970. 1 tab, 4 fig, 21 ref.

Descriptors: *Transpiration, *Evaporation, Water balance, Evapotranspiration, Consumptive use, Water loss.
Identifiers: Canopy resistance, Snap beans (Phaseolus vulgaris L.).

A model is described in which transpiration from a loosely structured canopy is calculated from the potential evaporation, the evaporation from the soil, and the stomatal resistance weighted by the leaf area index of the field. Estimation of the evaporation from the soil requires the net radiation at the soil surface and the surface soil water content. A test of the model on snap beans (Phaseolus vulgaris L.) resulted in a 4 percent overestimation attributed to the inaccuracy of the estimate of the evaporation from the soil.

70-71:02D-015
THE EVAPORATION FROM A SWAMP,
Linacre, E. T., Hicks, B. B., Sainty, G. R., and Grauze, G.
Macquarie University, North Ryde, N.S.W. (Australia), School of Earth Sciences.
Agricultural Meteorology, Vol. 7, No. 5, p 375-386, 1970. 4 tab, 22 ref.

Descriptors: Evaporation, Measurement, Swamp.
Identifiers: Swamp evaporation, Barren Box Swamp, New South Wales, Reeds.

The evaporation from an Australian swamp of area 3,000 ha has been measured over several daylight 1/2-h periods during three days in summer, at the same time as measurements of the evaporation from a lake 16 km away. The swamp evaporation was determined using an eddy-correlation instrument. This was used also in preliminary measurements at the lake, to verify the appropriate constant in a "bulk property"-formula for lake evaporation, enabling estimates to be made of the latter from measurements of wind travel, dry- and wet-bulb temperatures, and water surface temperature. The results suggest that, except immediately after rain, the swamp lost water at a rate significantly lower than the lake. This is attributed to the lower albedo of the clear water surface of the lake, the shelter given by the reeds in the swamp to the water surface and the internal resistance to water movement of the reeds themselves.

70-71:02D-016
CONSUMPTIVE USE OF WATER BY ALFALFA IN WESTERN NEBRASKA,
Daigger, L. A., Axthelm, L. S., and Ashburn, C. L.
Nebraska Agricultural Experiment Station, Mitchell.
Agronomy Journal, Vol. 62, No. 4, p 507-508, 1970. 4 tabs, 7 ref.
(See 70-71:03F-036)

70-71:02D-017
WATER STORAGE AND DRAINAGE UNDER A ROW CROP ON A SANDY SOIL,
Black, T. A., Gardner, W. R., and Tanner, C. B.
British Columbia University, Vancouver, Canada, Dept of Soil Science.
Agronomy Journal, Vol. 62, No. 1, p 48-51, 1970. 5 fig, 9 ref.
(See 70-71:02F-030)

70-71:02D-018
WATER USE AND SOIL WATER DEPLETION BY DRYLAND WINTER WHEAT AS AFFECTED BY NITROGEN FERTILIZATION,
Brown, P. L.
Agricultural Research Service, Bozeman, Montana.
Agronomy Journal, Vol. 63, No. 1, p 43-46, 1971. 2 tab, 3 fig, 8 ref.

Descriptors: *Nitrogen, *Water use, Fertilization, Wheat, Water uptake.
Identifiers: Water use efficiency, Nitrogen fertilization, Winter wheat (Triticum aestivum L. 'Winalta').

Evapotranspiration, daily water use, and soil water depletion by Feekes scale (7) growth stages of N-fertilized winter wheat (Triticum aestivum, L. 'Winalta') were measured under dryland field conditions. Fall-applied N (NH_4NO_3) rates were 0, 67, and 268 kg/ha (0, 60, and 240 lb/a). Soil water measurements were made at weekly intervals with a neutron moisture meter. Soil NO_3N to 183 cm (6 ft) in early spring was 21 kg/ha (19 lb/a). ET for the spring-summer growth period was 22.1, 27.2, and 31.5 cm (8.7, 10.7, and 12.4 in.) for the respective N treatments. Daily ET reached maximum values at the headed-to-flower stage. Soil water extraction was largely limited to the upper 91 cm (3 ft) with no N. With N, the wheat extracted water to 183 cm. Stored soil water supplied 6.1, 11.2, and 15.5 cm (2.4, 4.4, and 6.1 in.) of water to the wheat grown on the three N treatments. This was 30, 55, and 76% of the plant available water to 183 cm. At maturity, there was 18.0, 13.2, and 9.6 cm (7.1, 5.2, and 3.8 in.) of plant available water remaining in the soil to a depth of 183 cm. Grain yields were 1,610, 3,090, and 3,630 kg/ha (24, 46, and 54 bu/a). In addition to increasing ET, N increased water use efficiency by an average of 56%.

70-71:02D-019
MEASUREMENTS OF NON-POTENTAIL EVAPORATION FROM WHEAT,
Denmead, O. T., and McIlroy, I. C.
Commonwealth Scientific and Industrial Research Organization, Canberra, A.C.T. (Australia), Division of Plant Industry.
Agricultural Meteorology, Vol. 7, No. 4, p 285-302, 1970. 1 tab, 5 fig, 16 ref.

Descriptors: *Evaporation, Wheat, Measurement, Lysimeter, Hydrologic cycle.
Identifiers: Non-potential evaporation, Energy balance, Canberra Australia, Evaporation measurement methodology.

The reliability of the energy balance and lysimetric methods for measuring evaporation has been examined in experiments in a field of wheat. Net radiation tion, soil heat flux and evaporation, E, were measured, the last by means of a weighing lysimeter. Sensible heat flux, H, was obtained by difference in the energy balance equation, and H and E used to construct an experimental estimate of the Bowen ratio. A total of 210 hourly comparisons were made between lysimeter evaporation and calculated evaporation. Differences between E_b and E were generally within ± 0.1 mm/h. This difference was of the same magnitude as the estimated experimental error, and it is concluded both that E_b was a reliable estimate of E, and that the lysimeter itself was adequately representative of its surroundings. The paper also reports studies over 4 1/2 years of seasonal changes in evaporation and soil water storage in an agricultural system typical of land-use in the Canberra area.

70-71:02D-020
CONQUEST OF WASTES SHOW PRODUCTIVITY,
Hodge, Carl O., and Kassander, A. Richard, Jr.
University of Arizona, Tucson, Environmental Research Laboratory.
Reclamation Era, Vol. 57, No. 1, p 14-16, February 1971. 3 fig.

Descriptors: *Reclaimed water, *Water desalting, *Desalinization apparatus, Greenhouses, Growth chambers, Experimental farm, Mexico.
Identifiers: *Hydrophonics, Evapotranspiration control, Research stations, Sea water irrigation.

Successful food production using waste, water, heat, and land is claimed by a controlled atmosphere farming experiment located on the University of Sonora Research Station at Puerto Penasco on the Gulf of California. Waste heat from diesel-electric generators is used to desalt sea water which is then used for irrigation. Giant inflated bubbles of 12-mil polyethylene film serve as the greenhouses. The crops are planted in sterile beach sand and the required nutrients are supplied by adding them to the irrigation water. The water is transpired by the plant and trapped in the sealed greenhouse and recycled, thereby reducing the plant water requirements by 90 percent.

70-71:02D-021
EFFECTS OF SOIL TEXTURE ON EVAPORATIVE LOSS AND AVAILABLE WATER IN SEMI-ARID CLIMATES,
Alizai, H. U., and Hulbert, L. C.
Kansas State University, Manhattan.
Soil Science, Vol. 110, No. 5, p 328-332, November 1970. 2 fig, 4 tab, 14 ref.

Descriptors: *Evaporation, *Soil water-plant-relationships, Available water, Soil moisture, Soil science, Soil texture.
Identifiers: Coarse-textured soil, Fine textured soil.

Greenhouse experiments were conducted on three soils to test the effect of soil texture on evaporation. Evaporation was 3 times as great from the loams as from gravelly sand after adding equal amounts of water. Sorghum plants remained turgid in gravelly sand but wilted and died in loam supplied with equal amounts of water. This confirms that more water evaporates from fine-textured than from coarse textured soils.

70-71:02D-022
INTRODUCTION: MATHEMATICAL MODELING OF PLANTS,
Walker, J. N., and Splinter, W. E.
Kentucky University, Lexington.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5, p 945, May 1971.

Descriptors: *Mathematical models, *Computer models, Plant growth.

The reasons for and the validity of plant modeling are explained. An introduction to the articles that follow in this issue of the Transactions is presented. The articles and their authors are listed.

Section V

WATER CYCLE

STREAMFLOW AND RUNOFF (Group 02E)

70-71:02E-001
SURFACE RUNOFF FROM GRADED LANDS OF LOW SLOPES,
Laflen, J. M., and Saveson, I. L.
Transactions American Society of Agricultural Engineers, Vol. 13, No. 3, p 340-341, 1970. 4 fig, 2 ref.

Descriptors: *Mathematical studies, *Data collections, *Surface runoff, Estimating equations, Storms, Louisiana.
Identifiers: *Data analysis, Baton Rough, Louisiana

This paper reports on analysis of surface runoff data collected during 1962, 1963, and 1964 near Baton Rouge, Louisiana. The object of the data analysis was to develop reliable prediction equations for estimating peak rate and total amount of surface runoff from any storm. The hypothesis tested was that peak rate and total amount of surface runoff could be expressed as functions of precipitation, row slope, row length, and antecedent soil moisture. Some conclusions drawn from the experiment include: (1) the effect of antecedent soil moisture is independent of precipitation, if the peak rate of runoff is the dependent variable; (2) the effect of slope and length of surface runoff is not independent of precipitation; (3) a single, precipitation-intensity measure is sufficient for expressing the effect of precipitation on peak rate of surface runoff.

70-71:02E-002
THE FRICTION COEFFICIENT FOR SHALLOW FLOWS OVER A SIMULATED TURF SURFACE,
Phelps, H. O.
University of the West Indies, St. Augustine (Trinidad).
Water Resources Research, Vol. 6, No. 4, p 1220- 226, August 1970. 7 p, 2 fig, 1 tab, 7 ref.

Descriptors: *Overland flow, *Roughness (Hydraulic), *Turf, *Hydraulic models, Fluid friction, Reynolds number, Energy losses, Discharge (Water), Flow resistance, Hydraulics, Porous media, Flumes, Mathematical models, Laminar flow, Turbulent flow.
Identifiers: Overland flow over turf.

The friction coefficient of rough surfaces must be known for the application of the basic momentum and continuity equations to the modeling of overland flow. Flume experiments on steady, uniform flows in the laminar and transitional regions over a simulated turf surface provide the data required to investigate the general hydraulic roughness properties of natural turf, and the particular parameters that are likely to influence the friction coefficient. Because boundary geometry depends on flow depth, this factor must be considered in calculating the relationship between friction coefficient and Reynolds number. By maintaining constant depths while varying the Reynolds number, the separate effects of boundary geometry and Reynolds number on the friction coefficient are demonstrated. The results, which are presented in the form of a friction coefficient chart, may be rationally explained if the simulated turf is considered to be a complex porous medium in which the boundary geometry is variable.

70-71:02E-003
RUNOFF ANALYSIS BY ELECTRICAL CONDUCTANCE OF WATER,
Nakamura, R.
Tokyo University (Japan), Laboratory of Irrigation and Drainage.
Journal of Hydrology, Vol. 14, No. 3/4, p 197-212, December 1971. 9 fig, 2 tab, 11 ref.

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Descriptors: *Discharge measurement, *Rainfall-runoff relationships, *Water quality, *Electrical conductance, Model studies, Simulation analysis, water chemistry, Stream gages, Base flow.

By continuous measurement of conductance and discharge, the surface flow component could be separated from other components in the recession phase of hydrographs. The conductance-time curve and the hydrograph were both simultaneously simulated by a series of model reservoirs. The parameters of the model were adjusted by a trial-and-error method. The conductance factor used in this analysis made it possible to adjust rationally some of the runoff parameters. The portion of the zone wetted by runoff water within or on the surface of the soil expands according to the precipitation magnitude. Water storage which is consumed in a long period of dry weather does not yield runoff water during storms.

70-71:02E-004
PREDICTING IRRIGATION REQUIREMENTS OF CROPS,
David, W. P., and Hiler, E. A.
Iowa State University, Ames, Agricultural Engineering Department.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 96, No. IR3, Proc. Paper 7507, p 241-255, 1970. 3 tab, 10 fig, 2 append, 20 ref.
(See 70-71:03F-038)

70-71:02E-005
NOTES: HALF-MINUTE COUNTS FOR NEUTRON PROBES,
Rogerson, T. L.
United States Department of Agriculture Forest Service, Harrison, Arkansas.
Soil Science, Vol. 110, No. 5, p 359-360, November 1970. 2 tab, 4 ref.

Descriptors: *Soil moisture, *Nuclear moisture meters, Groundwater, Soil physics.
Identifiers: *Neutron probe.

A study was performed of how well the values of moisture content compared between one minute and one-half minute intervals using late model neutron probing equipment. Two holes six feet deep were compared for four weeks. The average absolute difference between the counting intervals was 0.017 inches of moisture or 0.28 percent of volume. The standard deviation was 0.27 percent. The study indicates that one-half minute counts are likely to be adequate for most purposes when late model probe systems are used.

70-71:02E-006
AGRICULTURALLY-POLLUTED IRRIGATION WATER AS A SOURCE OF PLANT PARASITIC NEMATODE INFESTATION,
Faulkner, L. R., Bolander, W. J.
Washington State University, Prosser, Irrigated Agriculture Research and Extension Center.
Journal of Nematology, Vol. 2, No. 4, p 368-374, October 1970. 2 fig, 3 tab, 5 ref.
(See 70-71:05B-026)

70-71:02E-007
SEDIMENT,
Robinson, A. R.
United States Department of Agriculture Sedimentation Laboratory, Oxford, Mississippi.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 61-62, March-April 1971. 8 ref.
(See 70-71:05B-031)

70-71:02E-008
A PRIMER ON AGRICULTURAL POLLUTION,
Wadleigh, C. H.
United States Department of Agriculture, Agricultural Research Service,
Beltsville, Maryland, Office of the Administrator.
In: Journal of Soil and Water Conservation, A Primer on Agricultural Pollution, Individual Papers, Vol. 26, No. 2, p 44-65, March-April 1971.
(See 70-71:05B-033)

70-71:02E-009
PREDICTION OF SEDIMENT YIELDS FROM SMALL WATERSHEDS,
Williams J. R., Hiler, E. A., Baird, R. W.
United States Department of Agriculture, Riesel, Texas.
Transactions of the American Society of Agricultural Engineers, Vol. 14, No. 6,
p 1157-1162, June 1971. 5 fig, 5 tab, 19 ref.

Descriptors: *Erosion, *Sediments, Soil conservation, Surface waters, Pollutants, Mathematical models.
Identifiers: *Watersheds, Pollution sources.

A procedure for predicting sediment yields from small watersheds has been developed. The results should be a better understanding of the factors that cause sediment yield and the development of sediment prediction equations for each physiographic area. Procedures for calculating sediment yields were presented. Several conclusions can be made as a result of this investigation. It is feasible to develop a procedure for predicting sediment yield from small watersheds based on climatic factors, watershed characteristics, and land use and treatment factors.

70-71:02E-010
OPERATION OF IRRIGATION SYSTEMS OUTSIDE THE GROWING SEASON,
Voropayev, G. V.
Soviet Hydrology: Selected Papers, No. 1, p 80-88, 1970. 6 fig, 4 tab.
(See 70-71:03F-060)

70-71:02E-011
QUALITY OF SURFACE IRRIGATION RUNOFF WATER,
Bondurant, J. A.
United States Department of Agriculture, Agricultural Research Service,
Kimberly, Idaho.
Transactions of the American Society of Agricultural Engineers, Vol. 14, No.
6, p 1001-1003, June 1971. 1 tab, 7 ref.
(See 70-71:05B-040)

70-71:02E-012
THE INFERENCE OF INTAKE AND HYDRAULIC ROUGHNESS PARAMETERS FROM PLOT RUNOFF USING KINEMATIC WAVE THEORY,
Burman, R. D., Black, R. D.
Wyoming University, Laramie.
Transactions of the American Society of Agricultural Engineers, Vol. 13, No. 4,
p 479-481, April 1970. 5 fig, 3 tab, 5 ref.

Descriptors: *Hydrology, *Computer models, *Surface runoff, Watersheds, Mathematical models.
Identifiers: *Hydrologic model, Intake rate, Hydraulic roughness.

Surface runoff from rainfall is strongly influenced by infiltration and hydraulic roughness. This study attempted to evaluate infiltration and hydraulic roughness on small plots by determining the values necessary to make a mathematical model fit experimental plot data. The model incorporates a finite difference approximation for the kinematic-wave equations. Infiltration in the model is characterized by Horton's equation, and the surface roughness and the unknowns in Horton's equation are derived by parameter optimization.

70-71:02E-013
LAND GRADING FOR IMPROVED SURFACE DRAINAGE,
Sewell, J. I.
Tennessee University, Knoxville.
Transactions of the American Society of Agricultural Engineers, Vol. 13, No. 6, p 817-819, June 1970. 2 fig, 4 tab, 4 ref.

Descriptors: *Land management, *Land forming, Surface drainage, Furrow drainage.
Identifiers: Land grading.

In 1962 a 123.4 acre plot of bottomland on the West Tennessee Experiment Station was graded. Rather extensive cutting and filling showed no significant adverse effects on corn silage yield during the first 3 years after land grading. However, these are deep alluvial soils with little profile development. The land could not have been improved sufficiently for mechanized operations without taking similar measures. Graded lands must be tilled in such a manner that back furrows or ridges are not created.

70-71:02E-014
SILT TRANSPORT BY THIN FILM FLOW,
Podmore, T. H., Merva, G. E.
Queensland Institute of Technology, Toowoomba, Australia.
Transactions of the American Society of Agricultural Engineers, Vol. 14, No. 6, p 1065-1072, June 1971. 6 fig, 2 tab, 15 ref.

Descriptors: *Erosion, *Soil conservation, Water pollution sources, Sheet erosion, Silts.

The study was made to obtain information on intermediate stages of the erosion process involving the transport of eroded materials by thin film flow. The use of Stokes Law as a model for the sedimentation process leading to deposition of suspended material was inadequate. A "Critical Distance" was defined as the distance from the point of insertion of sediment in the flowing film to the point at which a maximum amount of material is deposited for a predetermined particle size range. A Coulter Counter was used to analyze small amounts of suspended material. It was concluded that: (1) Critical Distance is generally independent of particle size. (2) Critical Distance decreases with increasing surface roughness. (3) Critical Distance generally increases with increasing slope. (4) Stokes Law does not yield a satisfactory model of the sediment transport mechanism. (5) The Coulter Counter can be utilized for particle size anlaysis of small amounts of suspended silt.

70-71:02E-015
MOVEMENT OF AGRICULTURAL FERTILIZERS AND ORGANIC INSECTICIDES IN SURFACE RUNOFF,
Sievers, D. M., Lentz, G. L., Beasley, R. P.
Missouri University, Columbia.
Transactions of the American Society of Agricultural Engineers, Vol. 13, No. 3, p 323-325, March 1970. 6 fig, 1 tab, 7 ref.
(See 70-71:05B-049)

70-71:02E-016
SALINITY AND THE HYDROLOGIC CYCLE,
Holmes, J. W.

Flinders University, South Australia. School of Physical Sciences.
Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971. Canberra, Australia, p 25-40. 6 fig, 8 tab, 21 ref.
(See 70-71:02A-004)

70-71:02E-017
THE TRANSPORT OF SALT IN RIVERS AND ESTUARIES,
Wood, I. R.
New South Wales University, Manly Vale, Australia, Water Research Laboratory.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 141-157. 8 fig, 30 ref.
(See 70-71:01B-005)

70-71:02E-018
EFFECT OF VEGETAL LENGTH AND SPATIALLY VARIED FLOW ON VELOCITY DISTRIBUTION COEFFICIENTS,
McCool, D. K.
United States Department of Agriculture, Stillwater, Oklahoma.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5, p 603-607, May, 1970. 9 fig, 4 tab, 14 ref.
(See 70-71:08A-003)

SECTION VI

WATER CYCLE

GROUNDWATER (Group 02F)

70-71:02F-001
MATHEMATICAL ANALYSIS OF GROUNDWATER RECHARGE,
Matlock, W. G.
Arizona University, Tucson, Dept of Agricultural Engineering.
Transactions of the American Society of Agricultural Engineers, Vol. 13, No. 6, p 785-787, 791, 1970. 5 fig, 1 tab, 10 ref.

Descriptors: *Groundwater recharge, *Mathematical model, *Ephemeral streams, *Arizona, Groundwater movement, Aquifer characteristics, Natural recharge, Hydrogeology, Hydrology, Water level fluctuations, Snowmelt.
Identifiers: *Rillito Creek Basin (Arizona).

The rise of groundwater levels caused by recharge from Rillito Creek in Arizona is described by a mathematical model. Rillito Creek is an ephemeral stream with a total drainage area of 918 square miles in the semiarid part of southern Arizona. The system is unique because of the dual nature of the flows it carries. Of the total drainage area, 183 square miles are mountainous, 40 square miles of which are above 6,000 feet. At this elevation appreciable snowfall occurs each winter in all but the driest years. Consequently, considerable runoff from snow melt reaches Rillito Creek. The clear flow from snow melt infiltrates rapidly, seldom leaving the drainage area. On the other hand, summer floods following intense thunderstorms are more violent and of shorter duration.

70-71:02F-002
PARAMETER ESTIMATION IN HYDROLOGY: THE STATE OF THE ART,
Jackson, Donald R., and Aron, Gert.
Pennsylvania State University, University Park, Dept of Civil Engineering.
Water Resources Bulletin, Vol. 7, No. 3, p 457-472, June 1971. 16 p, 1 fig, 47 ref.

Descriptors: *Aquifer characteristics, *Mathematical models, *Analog models, *Transmissivity, *Storage coefficient, Estimating, Permeability, Water levels, Water yield, Drawdown, Groundwater movement, Hydrogeology.
Identifiers: *Aquifer evaluation, Pumping tests.

A detailed review of current methods and criteria used in parameter estimation in hydrology is presented. The effect of errors in the data set and the effect of interactions between methods of analysis, criteria, data set errors, and modeling assumptions are reviewed and discussed briefly. It is concluded that study techniques criteria, data set errors, and particularly interactions between these, is essential to further progress in hydrologic modeling.

70-71:02F-003
PARAMETER ESTIMATION FOR AQUIFER EVALUATION,
Sternberg, Yaron M.
Maryland University, College Park, Dept of Civil Engineering.
Water Resources Bulletin, Vol. 7, No. 3, p 447-456, June 1971. 10 p, 2 tab, 47 ref.

Descriptors: *Aquifer characteristics, *Mathematical models, *Analog models, *Transmissivity, *Storage coefficient, Estimating, Permeability, Water levels, Water yield, Drawdown, Groundwater movement, Hydrogeology.
Identifiers: *Aquifer evaluation, Pumping tests.

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The various tools and techniques available for evaluation of aquifers are reviewed. Data for evaluation studies can be obtained from laboratory experiments, geological maps, well logs and field studies. Such data can be used in analytic or electric analog models to determine the sustained yield of the aquifer under various operating conditions. Geologic maps provide data on the type of formation and its make up. Well logs give detailed information on the lithology at a particular location. Data from a number of well logs of the aquifer can delineate the dimensions of the aquifer. The aquifer characteristics can be determined from field pumping tests or obtained indirectly from laboratory experiments. Pumping tests can also indicate the presence of a geologic boundary such as an impermeable boundary. For aquifers with relatively simple geometric boundaries and aquifer characteristics, a mathematical model is generally adequate for estimating the water yield. For more complex aquifers where for example salt water intrusion may pose a problem, more detailed information can be obtained by using an electric analog model. Thus the accuracy of the desired information must determine the type of model to use and the quantity of the basic data required.

70-71:02F-004
DRAINAGE OF GROUNDWATER RESTING ON A SLOPING BED,
Childs, E. C.
Cambridge University (England), Dept of Agricultural Science; and Dept of Applied Biology.
Water Resources Research, Vol. 7, No. 5, p 1256-1263, October 1971. 5 fig, 1 tab, 11 ref.

Descriptors: *Dupuit-Forchheimer theory, *Aquicludes, *Slopes, Drainage, Groundwater movement, Hydraulic gradient, Water levels, Mathematical studies.

The Dupuit-Forchheimer convention for horizontal impermeable beds states that the gradient of hydraulic potential is synonymous with the absolute slope of the water table. When the impermeable bed is sloping, however, the gradient is normally better approximately by dZ/dl, where l is the distance measured along the bed and Z is the height of the intersection with the water table of the perpendicular through l. Thus, the solution of the resulting flow equation for drainage to a transverse ditch in the absence of surface recharge provides a family of branched curves for different slopes, instead of the single branched curve currently accepted.

70-71:02F-005
APPLICATION OF A LOCAL SIMILARITY CONCEPT IN SOLVING THE VERTICAL SUBSURFACE FLOW PROBLEM,
Drake, R. L., and Peterson, C. P.
National Center for Atmospheric Research, Boulder, Colorado.
Water Resources Research, Vol. 7, No. 5, p 1241-1255, October 1971. 18 fig, 1 tab, 14 ref.

Descriptors: *Mathematical studies, Continuity equation, Equations, Groundwater movement, Infiltration, Approximation method, Numerical analysis, Estimating, Mathematical models.
Identifiers: Continuum mechanics.

Similarity transformations may be used even when all the requirements for the application of such transformations are satisfied. The transformed equations usually involve a stray time variable that is interpreted as a system parameter. When this parameter is properly interpreted, the solutions of the transformed systems are very good numerical approximations for the solutions of the original systems. The advantages of considering the transformed systems are usually two-fold: numerical solutions can be obtained with less computer time, and qualitative analysis of the transformed systems is usually easier than that of the original systems. A local similarity concept may be used in solving evolution-type problems in continuum mechanics, including the Fokker-Planck equation of vertical subsurface flow.

70-71:02F-006
COMMENTS ON THE STABLE ISOTOPE METHOD IN REGIONAL GROUNDWATER INVESTIGATIONS,
Gat, J. R.
International Atomic Energy Agency, Vienna (Austria).
Water Resources Research, Vol. 7, No. 4, p 980-993, August 1971. 4 fig, 43 ref.

Descriptors: *Stable isotopes, *Oxygen, *Deuterium, *Groundwater movement, Groundwater basins, Tracers, Tracking techniques, Surveys, Reviews, Mixing, Water chemistry, Hydrogeology, Provenance, Statistics, Regional analysis.
Identifiers: Isotope hydrogeology.

Comparison of natural variations of oxygen 18 and deuterium abundances in groundwaters to those of the local precipitation may be used as a hydrologic tool. The residual scatter in time and space of the isotope content of groundwater sources is a measure of the homogeneity of these systems rather than of their age or size. The concept of a regional slope of evaporation lines on deuterium versus O-18 diagrams, has only limited validity. Isotope criteria are suggested for distinguishing rainfall from past climatic periods. As a result of the unsteady nature of the mechanisms affecting the isotope composition of groundwaters, their most reliable use under the limitations of our present quantitative knowledge on the causes of this scatter is as classifying parameters in regional investigations.

70-71:02F-007
MEASUREMENT OF VERTICAL GROUNDWATER VELOCITY FROM TEMPERATURE PROFILES IN WELLS.
Sorey, M. L.
Geological Survey, Denver, Colorado, Water Resources Division.
Water Resources Research, Vol. 7, No. 4, p 963-970, August 1971. 8 fig, 14 ref.

Descriptors: *Groundwater movement, *Geothermal studies, *Temperature, *Borehole geophysics, *Instrumentation, Colorado, New Mexico, Velocity, Observation wells, Heat flow.
Identifiers: Vertical groundwater movement.

Vertically moving groundwater transports heat by convection and causes curvature in the earth's thermal profile. Dimensionless plots of the temperature distribution in wells can be matched with published type curves to obtain solutions for vertical groundwater velocity if the thermal conductivity of the solid-fluid complex is known or can be estimated. Rates of upward movement through semiconfining beds determined from temperature studies in the San Luis valley of Colorado and the Roswell basin of New Mexico were in good agreement with rates computed from pumping tests and water budget methods. Limitations of the method result from instability in borehole fluids, measurement detail required, and magnitudes of flow that can be detected.

70-71:02F-008
OPTIMAL IDENTIFICATION OF AQUIFER DIFFUSIVITY USING QUASILINEARIZATION,
Yeh, W. W-G., and Tauxe, G. W.
California University, Los Angeles.
Water Resources Research, Vol. 7, No. 4, p 955-962, August 1971. 6 fig, 4 tab, 12 ref.

Descriptors: *Groundwater movement, *Diffusivity, *Surface-groundwater relationships, Numerical analysis, Parametric hydrology, Mathematical models, Mathematical studies, Dupuit-Forchheimer theory, Linear programming, Optimization, Hydrographs, Stage-discharge relations.
Identifiers: *Parameter identification.

An analytical procedure is presented to solve the problem of identifying aquifer diffusivity in an unconfined aquifer and stream interaction system using the fluctuation of the aquifer head in response to a flood wave as data. The governing nonlinear partial differential equation is replaced by a system of nonlinear ordinary differential equations to which the technique of quasilinearization is applied. The procedure is straightforward and converges quadratically. It requires neither graphical matching nor trial and error manipulations. Numerical experiments are presented and compared with published experimental data.

70-71:02F-009
SEEPAGE THROUGH UNCONFINED AQUIFERS WITH LOWER BOUNDARIES OF ANY SHAPE,
Youngs, E. G.
Agricultural Research Council, Cambridge (England), Unit of Soil Physics.
Water Resources Research, Vol.7, No.3, p 624-631, June 1971. 8 p, 8 fig, 8 ref.

Descriptors: *Groundwater movement, *Seepage, *Underseepage, *Aquicludes, Dams, Canals, Canal seepage, Soil water movement, Saturated flow, Unsaturated flow, Equations, Porous media, Hydraulic conductivity, Water table, Saline water intrusion, Boundary processes, Dupuit-Forchheimer theory, Stratified flow.
Identifiers: Unconfined aquifers.

Seepage through unconfined aquifers with lower boundaries of any shape is analyzed. The differential equation describing the flow includes a term that involves the pressure distribution on the lower boundary. Although in many problems all the required pressure distribution that enable the seepage problem to be solved are not known exactly, inspection of a given problem gives extreme values of any unknown terms with a final result of known precision. The application of the analysis, checked by electric analog experiments, is illustrated by two examples of seepage problems: first, the seepage over an inclined plane between two parallel ditches; and second, the seaward flow of freshwater fed by a freshwater reservoir or by rainfall and supported on saline water from the sea.

70-71:02F-010
THREE-DIMENSIONAL, TRANSIENT, SATURATED-UNSATURATED FLOW IN A GROUNDWATER BASIN,
Freeze, R. Allan
Thomas J. Watson Research Center, Yorktown Heights, New York.
Water Resources Research, Vol.7, No.2, p 347-366, April 1971. 20 p, 11 fig, 34 ref.

Descriptors: *Groundwater basins, *Hydrogeology, *Mathematical models, *Simulation analysis, *Numerical analysis, Groundwater movement, *Aquifers, Surface-groundwater relationships, Saturated flow, Rainfall-runoff relationships, Water yield, Safe yield, Computer programs, Water levels, Hydraulic gradient, Unsteady flow, Base flow, Water balance.
Identifiers: Transient flow.

A three-dimensional finite difference model was developed for the treatment of saturated-unsaturated transient flow in small nonhomogeneous, anisotropic geologic basins. The model includes the unsaturated zone in a basin-wide model that can also handle both confined and unconfined saturated aquifers, under both natural and developed conditions. The integrated equation of flow is solved by the line successive overrelaxation technique. The model allows any generalized region shape and any configuration of time variant boundary conditions. When applied to natural flow systems, the model provides quantitative hydrographs of surface infiltration, groundwater recharge, water table depth, and base flow. Results of simulations for hypothetical basins provide insight into the mechanisms involved in the development of perched water tables. The unsaturated basin response is the controlling factor in determining the nature of the base flow hydrograph. Application of the model to developed basins allows simulation of the manner in which groundwater withdrawals are transmitted through the aquifers and the changes in the rates of groundwater recharge and discharge induced by the withdrawals. For any proposed pumping pattern, it is possible to predict the maximum basin yield that can be sustained by a flow system in equilibrium with the recharge-discharge characteristics of the basin.

70-71:02F-011
EFFECT OF SOIL MOISTURE HYSTERESIS ON THE WATER TABLE PROFILE AROUND A GRAVITY WELL,
Guitjens, J. C., and Luthin, James N.
Nevada University, Reno. Plant, Soil, and Water Science Division and California University, Davis, Dept of Water Science and Engineering.
Water Resources Research, Vol. 7, No. 2, p 334-346, April 1971. 13 p, 8 fig, 2 tab, 21 ref, 3 append.

Descriptors: *Hysteresis, *Soil water movement, *Drawdown, *Water table, *Water level fluctuations, Withdrawal, Surface-groundwater relationships, Infiltration, Seepage, Recharge, Soil moisture, Specific capacity, Time lag, Aquifer characteristics, Groundwater movement.
Identifiers: *Soil moisture-groundwater relations, *Gravity wells.

Gravity wells, pumped intermittently, can have different degrees of drainage in the unsaturated zone at the onset of water table recovery. Each part of the aquifer profile follows a specific curve of rewetting. Measured hysteresis of fine sand and hydraulic conductivity as a function of moisture content are incorporated in the partial differential equations for steady and unsteady radial flow to solve for the soil moisture pressure distribution of water table drawdown and three different kinds of recovery. The method of independent domains describes hysteresis and accounts for a gradual release and uptake of water rather than constant changes based on the concept of specific yield. Small differences between the computed values of the three water table recoveries, each one starting at a different degree of drainage in the zone above the water table, are probably due to the relatively small unsaturated portion of the aquifer profile.

70-71:02F-012
PERTURBATION SOLUTIONS OF THE DISPERSION EQUATION IN POROUS MEDIUMS,
Dagan, Gedeon.
Technion-Israel Institute of Technology, Haifa.
Water Resources Research, Vol. 7, No. 1, p 135-142, February 1971. 8 p, 3 fig, 18 ref.

Descriptors: *Dispersion, *Porous media, *Groundwater movement, Equations, Hydrogeology, Darcys law, Mathematical studies, Boundary layers, Flow nets, Flow, Velocity, Percolation, Steady flow, Tracers.
Identifiers: Dispersion equations.

The solution of the dispersion equation for porous media is difficult because of the dependence of the dispersion tensor on the velocity. Approximate solutions of dispersion in nonuniform two-dimensional flows are sought by perturbation expansions. An inner boundary layer solution for the transition zone between two fluids in steady and unsteady conditions is derived. Two examples of dispersion, radial flow and coastal aquifers, are solved approximately.

70-71:02F-013
SPACING OF DRAINAGE WELLS IN A LAYERED AQUIFER,
Khan, Muhammed Yunus, and Kirkham, Don.
Iowa State University, Ames, Dept of Agronomy.
Water Resources Research, Vol. 7, No. 1, p 166-183, February 1971. 18 p, 5 fig, 2 tab, 10 ref, 2 append.

Descriptors: *Groundwater movement, *Aquifers, *Withdrawal, *Hydrogeology, *Drainage wells, Equations, Mathematical studies, Permeability, Isotopy, Drawdown, Recharge, Drainage systems, Pumping, Subsurface drainage, Water table, Saturated flow, Computer programs, Steady flow, Uniform flow.
Identifiers: Groundwater-soil water relationships.

A theory is presented to determine spacing of identical drainage wells that, by discharging groundwater simultaneously from a layered aquifer, will lower a water table to a preassigned level and maintain it. The theory has been developed by solving a mathematical boundary value problem. The wells are located on a certain regular grid, and the aquifer receives a uniform vertical recharge from rainfall or excess irrigation. The theory shows that the spacing depends on the thickness and hydraulic conductivity of each permeable layer tapped by the wells, the maximum allowable drawdown, the uniform vertical recharge, the radius of the wells, and the well grid geometry. A table of values of a function, useful for determining spacing of wells to be tapped in an aquifer that may consist of any number of permeable layers, is given.

70-71:02F-014
FIELD AND LABORATORY DETERMINATION OF THE HYDRAULIC DIFFUSIVITY OF A CONFINING BED,
Wolff, Roger G.
Geological Survey, Washington, D.C.
Water Resources Research, Vol.6, No.1, p 194-203, February 1970. 10 p, 12 fig, 1 tab, 14 ref.

Descriptors: *Hydrogeology, *Groundwater movement, *Aquitards, *Diffusivity, On-site tests, Laboratory tests, Hydraulic conductivity, Storage coefficient, Observation wells, Piezometers, Model studies, Mathematical models.
Identifiers: Aquifer testing, Hydraulic diffusivity.

Field and laboratory evaluations of the hydraulic diffusivity of a confining bed are presented. The field approach consisted of measuring the head in the confining layer by placing piezometers equipped with differential pressure transducers at different depths in the confining layer. Pumping from the overlying aquifer resulted in an observed head change at the aquifer confining bed interface which for long periods of time could be approximated by a step drawdown. The best fit of observed data to the set of theoretical type curves for the step drawdown solution yields a hydraulic diffusivity 0.029 sq cm/sec. Hydraulic diffusivity values for the natural effective load, as obtained in the laboratory using consolidation techniques, are in general agreement with this result. Hydraulic conductivity values as determined in the laboratory by consolidation and constant flow methods are generally similar for the same sample. Particle size distribution and the clay mineralogy are also given for each sample.

70-71:02F-015
THE MECHANISM OF NATURAL GROUNDWATER RECHARGE AND DISCHARGE: 2. LABORATORY COLUMN EXPERIMENTS AND FIELD MEASUREMENTS,
Freeze, R. Allan, and Banner, James.
Department of Energy, Mines, and Resources, Calgary (Alberta), Inland Water Branch.
Water Resources Research, Vol.6, No.1, p 138-155, February 1970. 18 p, 10 fig, 3 tab, 19 ref.

Descriptors: *Recharge, *Discharge (Water), *Groundwater movement, *Infiltration, Laboratory tests, Model studies, On-site tests, Surveys, Investigations, Observation wells, Grasslands, Mathematical models, Snowmelt, Precipitation (Atmospheric), Saturated flow, Unsaturated flow, Evaporation, Sands, Hydrologic budget, Water balance.
Identifiers: Canada.

A mathematical model was used to simulate one-dimensional, vertical, unsteady, unsaturated flow above a recharging groundwater flow system. Results from this model were correlated with the results from a laboratory column experiment using a tensiometer-transducer system. On the Canadian prairies, cases of recharge-sustaining infiltration to the water table are isolated in time and space. Only spring snowmelt, and on occasion heavy summer rains, are effective. A large percentage of the snowmelt, however, is at the surface prior to the thawing of the frost wedge and therefore does not infiltrate.

Effective infiltration is largely in depressions, and some groundwater recharge areas may never receive direct infiltration to the water table. Observation well hydrographs of water-table fluctuations alone are not sufficient to monitor recharge phenomena; measurements of the hydraulic gradient above and below the water table are necessary. It is erroneous to map a sand or gravel plain as an effective recharge area without first investigating the influence of the unsaturated hydrologic properties of the soil.

70-71:02F-016
HYDRODYNAMIC INSTABILITY OF MISCIBLE FLUIDS IN A VERTICAL POROUS COLUMN,
Bachmat, Y. and Elrick, D. E.
Guelph University (Ontario).
Water Resources Research, Vol. 6, No. 1, p 156-171, February 1970. 16 p, 9 fig, 3 tab, 8 ref.

Descriptors: *Saline water intrusion, *Porous media, *Groundwater movement, Dispersion, Diffusion, Hydrodynamics, Model studies, Hydraulic models, Solutes, Mixing, Aqueous solutions, Mathematical models, Tracers, Dye releases, Hydraulic conductivity, Mathematical studies.
Identifiers: Hydrodynamic instability.

A series of experiments have been conducted at a constant temperature on the intrusion of salt from a reservoir containing a fixed volume of solution into an underlying long vertical column of porous material, initially saturated with pure water and sealed at the bottom. The variation with time of the salt concentration in the reservoir was measured for different types of porous materials, different initial concentrations, and different mechanical treatments of the solutions. The experimental results, substantiated by the theoretical analyses, indicate that the main contributor to the influx of salt into the porous material is the convective dispersion arising from the onset of horizontal variations of the salt concentration and of the vertical velocity component. Approximate expressions have been derived for the rate of decrease of the salt concentration in the reservoir, for the influx of salt into the porous material, and for the advances of the salt front within it.

70-71:02F-017
TWO-DIMENSIONAL DISPERSION EXPERIMENTS IN A POROUS MEDIUM,
Bruch, John C., Jr.
California University, Santa Barbara.
Water Resources Research, Vol. 6, No. 3, p 791-800, June 1970. 10 p, 7 fig, 1 tab, 9 ref.

Descriptors: *Dispersion, *Porous media, *Groundwater movement, Convection, Seepage, Mixing, Flow, Density, Viscosity, Model studies, Hydraulic models, Laboratory tests.
Identifiers: Two-dimensional dispersion.

A series of two-dimensional dispersion experiments were performed in a one-and-two-layered porous medium. The experimental results were compared with a theoretical and a numerical solution both of which describe the two-dimensional dispersion of a miscible, second fluid through a unidirectional seepage flow. The combined effect of longitudinal and lateral dispersion was considered in all cases. The experimental results and their comparisons with the numerical values clearly demonstrate the need to consider the combined effect of longitudinal and lateral dispersion in the analysis of the propagation of a miscible fluid in groundwater flow. If lateral dispersion were not considered, there would be no salt concentration at the position discussed. These, as well as the other results presented, also verify the use of the theoretical solution and the numerical scheme as accurate models for the two-dimensional dispersion phenomenon.

70-71:02F-018
FINGER IMBIBITION IN ARTIFICIAL REPLENISHMENT OF GROUNDWATER THROUGH CRACKED POROUS MEDIUM,
Verma, A. P.
Maharaja Sayajirao University of Baroda (India).
Water Resources Research, Vol. 6, No. 3, p 906-911, June 1970. 6 p, 3 fig, 20 ref.

Descriptors: *Groundwater movement, *Injection wells, *Mathematical models, *Mixing, Saline water intrusion, Porous media, Fractures (Geology), Permeability, Immiscibility, Viscosity, Water properties, Wettability, Wetting.
Identifiers: Imbibition (Groundwater).

A theoretical model of groundwater replenishment in a cracked porous medium considers simultaneous occurrence of the phenomena of fingering and imbibition. Injection of water into other water bodies is initiated by imbibition, and the injected and native water form two immiscible liquid phases of different salinities with small viscosity difference. For the average behavior of fingering, the nonlinear differential equation is solved by a perturbation technique. An expression for the average cross-sectional area occupied by fingers was obtained.

70-71:02F-019
EMPIRICAL RELATIONS IN PROPERTIES OF UNCONSOLIDATED QUARTZ SANDS AND SILTS PERTAINING TO WATER FLOW,
Wiebenga, William A., Ellis, W. R., and Kevi, L.
Bureau of Mineral Resources, Geology and Geophysics, Canberra (Australia); and Australian Atomic Energy Commission Research Establishment, Lucas Heights.
Water Resources Research, Vol. 6, No. 4, p 1154-1161, August 1970. 8 p, 6 fig, 2 tab, 9 ref.

Descriptors: *Groundwater movement, *Dupuit-Forchheimer theory, *Tracers, Hydrogeology, Particle size, Porosity, Radioisotopes, Permeability, Velocity Flow, Specific yield, Sediments, Aquifers, Laboratory tests, Hydraulic conductivity.
Identifiers: Sorting coefficient.

During a laboratory investigation using radiotracers, empirical formulas were developed to replace the ambiguous or incorrect Dupuit-Forchheimer assumption used in relationships governing the flow of water through porous, unconsolidated materials ranging from clay to coarse sands or fine gravels. The Dupuit-Forchheimer assumption states that the ratio of specific flow rate to average flow velocity is equal to porosity, but it is not specified whether true porosity or void ratio or specific yield, also called effective porosity, is meant. The hydraulic conductivity shows a good correlation with the maximum 10 percent grain size, and the ratio of specific flow rate to average flow velocity shows good correlation with functions of specific yield and percentile sorting coefficient. From field measurements of specific flow rate and average flow velocity the specific yield can be computed.

70-71:02F-020
THE USE OF LINEAR PROGRAMMING FOR ESTIMATING GEOHYDROLOGICAL PARAMETERS OF GROUNDWATER BASINS,
Kleinecke, David.
General Electric Company, Santa Barbara, California, Center for Advanced Studies.
Available from National Technical Information Service as PB-195 668, $3.00 in paper copy, $0.95 in microfiche. TEMP Report 70TMP-43, July 1970. 31 p, 1 tab, 8 ref.

Descriptors: *Aquifer characteristics, *Computer models, Data collections, Groundwater movement, *Groundwater basins, *Hydrogeology, *Linear programming, *Mathematical models, Model studies, *Simulation analysis.

Simulation models of groundwater basins require estimates of geohydrological parameters such as permeability and storage capacity. In present practice these parameters are initially guessed at and later adjusted by trial and error to improve the model's ability to simulate some known portion of the water history. It has been suggested that this process might be reversed to deduce geohydrology directly from the historical record. This suggestion was tested against a basin studied earlier by the California State Department of Water Resources. The fitting criteria used gave rise to linear programming formulations which were solved from the basin data. The approach shows promise in that about one-third of the basin parameters were evaluated, but further development is required. It is believed that historical records, although apparently overdetermining the system of equations, actually underdetermine the system because of redundancy effects. The approach appears to offer the best known method for estimating the effective aquifer depth.

70-71:02F-021
ANALYSIS OF GROUNDWATER FLOW TO DEEP WELLS IN AREAS WITH A NON-LINEAR FUNCTION FOR THE SUBSURFACE DRAINAGE,
Ernst, L. F.
Institute for Land and Water Management Research, Wageningen (Netherlands).
Journal of Hydrology, Vol. 14, No. 2, p 158-180, November 1971. 11 fig, 23 ref.

Descriptors: *Drawdown, *Water level fluctuations, *Infiltration, *Groundwater movement, *Withdrawal, Water wells, Water yield, Transmissivity, Flow, Aquifer characteristics, Water level fluctuations, Water table.

Quantitative analysis of groundwater flow to deep wells in areas where the excess precipitation is discharged largely by surface infiltration requires information about the system of surface drainage. The nonlinear relation between the discharge and the phreatic level can be explained by the fact that the length of the drains varies in the same sense as the discharge and the phreatic level. There is some evidence that the amplitude of the seasonal fluctuations of the phreatic surface will not be influenced very much when there is a constant pumping of water from deep wells. When the relation between hydraulic head and discharge by drains is linearized, the basic differential equation is reduced to a Bessel equation of zero order.

70-71:02F-022
ESTIMATING INFILTRATION AND/OR THE PARAMETERS OF UNCONFINED AQUIFERS FROM GROUNDWATER LEVEL OBSERVATIONS,
Venetis, C.
Journal of Hydrology, Vol. 12, No. 2, p 161-169, January 1971, 9 p, 2 fig, 2 tab, 3 ref.

Descriptors: *Groundwater movement, *Infiltration, *Water level fluctuations, Hydraulic gradient, Permeability, Transmissivity, Water balance, Storage coefficient, Aquifers, Water table, Water levels.
Identifiers: Unconfined aquifers.

The mechanism of the interplay between groundwater recharge and depletion is examined and simple practical methods are developed for the estimation of infiltration from groundwater level observations. Estimates of the aquifer parameters may also be obtained when a long term water balance is possible. The relationship between infiltration and groundwater levels is analyzed through the linear differential equation of the groundwater flow. The theoretical results are simplified by approximation, and the parameters involved are lumped into three constants which depend only on the relative position of the point of observation. These can be directly estimated from the recession of recorded groundwater levels and a longterm water balance.

70-71:02F-023
A PROPOSED TECHNIQUE FOR IDENTIFICATION OF UNCONFINED AQUIFER PARAMETERS,
Yeh, William W-G., and Tauxe, George W.
California University, Los Angeles.
Journal of Hydrology, Vol. 12, No. 2, p 117-128, January 1971. 12 p, 2 fig, 2 tab, 8 ref.

Descriptors: *Linear programming, *Parametric hydrology, *Groundwater movement, *Computer programs, *Mathematical models, Systems analysis, Numerical analysis, Aquifers, Least squares method, Equations, Mathematical studies, Unsteady flow.
Identifiers: Quasilinearization.

The technique of quasilinearization is applied to the problem of identifying the parameters in an unconfined aquifer system. This new technique is shown to be a very effective way of converting field observations based upon pumping tests into the desired aquifer parameters. The procedure is straightforward as it requires neither curve plotting nor graphical matching. The parameters to be identified are the hydraulic conductivity and specific storage in an extensive unconfined aquifer system. Results and numerical experiments are presented.

70-71:02F-024
BLOTTING PAPER MODELS SIMULATING GROUNDWATER FLOW,
Sevenhuysen, R. J.
Agricultural University, Wageningen (Netherlands).
Journal of Hydrology, Vol. 10, No. 3, p 276-281, April 1970. 6 p, 5 fig.

Descriptors: *Groundwater movement, *Hydraulic models, Model studies, Soil water movement, Infiltration, Saturated flow, Leaching.
Identifiers: Blotting paper models.

To demonstrate water flow in a cross-sectional model, use can be made of a heavy blotting paper. This material is easily cut into any shape, lines can be drawn on it, and samples can be taken out. The sheets of blotting paper, forming the model, are hung vertically, the flow is introduced by saturated sheets placed vertically or horizontally as required. Simulation of infiltration, saturated flow and leaching is described.

70-71:02F-025
THE POISEUILLE ANALOGUE FOR FLOW OF WATER IN WYOMING BENTONITE,
Blackmore, A. V.
Commonwealth Scientific and Industrial Research Organization, Griffith (Australia). Division of Soils.
Journal of Hydrology, Vol. 11, No. 1, p 59-68, July 1970. 10 p, 2 fig, 1 tab, 22 ref.

Descriptors: *Groundwater movement, *Bentonite, *Hydraulic gradient, Darcy's law, Hydrostatic pressure, Porosity, Ion transport, Clays, Porous media, Ion exchange, Membrane processes, Viscosity, Osmosis.
Identifiers: Poiseuille flow.

Water movement, parallel to the plane of orientation, is measured in a Wyoming bentonite as a function of hydrostatic pressure gradient and interparticle spacing; a simple system and technique are used so that some of the difficulties normally associated with the movement of water through reactive materials are avoided. The data are interpreted with the object of establishing a mathematical model based on the silt analogue of the Poiseuille equation, modified for electro-osmosis and anomalous viscosity, as suggested by Kemper. Pore velocity, at constant spacing, is very nearly proportional to pressure gradient (Darcy's law) while at constant pressure gradient it is linearly related to the square of the spacing. When the implications of these results are applied to the analogue an expression is obtained that describes the flow in a satisfactory manner. This expression is compared with one developed for flow in inert materials both within and beyond the limits of the present experiment.

70-71:02F-026
NUMERICAL MODELING OF UNSATURATED GROUNDWATER FLOW AND COMPARISON OF THE MODEL TO A FIELD EXPERIMENT,
Green, Don W., Dabiri, Hassan, Weinaug, Charles F., and Prill, Robert.
Kansas University, Lawrence, and Geological Survey, Garden City, Kansas.
Water Resources Research, Vol.6, No.3, p 862-874, June 1970. 13 p, 13 fig, 2 tab, 19 ref.

Descriptors: *Groundwater movement, *Soil water movement, *Surface-groundwater relationships, *Unsaturated flow, *Mathematical models, Computer models, On-site tests, Wetting, Drying, Pit recharge, Ponds, Recharge, Percolation, Numerical analysis, Porous media.
Identifiers: 2-phase flow (Soil water).

A mathematical model describing isothermal, two-phase flow in porous media consists of differential equations, using algorithms for their numerical solution. It was applied to the problem of vertical groundwater movement in unsaturated soils in the absence of evaporation and transpiration. The equations describing water-air flow through porous media are second order, nonlinear partial differential equations. These equations were converted to finite difference form and were solved with the aid of a digital computer using an iterative implicit procedure. The model includes effective permeabilities of each phase and capillary pressure as functions of liquid saturation. The properties of the porous media may be varied in the model as functions of position. A comparison was made between computed results and experimental field data on moisture movement beneath a shallow surface pond. Water was added to the pond at controlled rates to maintain an approximately constant head for a set time period. Following this wetting period the pond was kept dry, but covered to reduce evaporation. The experiment was simulated with the computer model and excellent agreement between calculated results and the data was obtained.

70-71:02F-027
ANALYSIS OF DATA FROM PUMPING TESTS IN UNCONFINED ANISOTROPIC AQUIFERS,
Boulton, Norman S.
Journal of Hydrology, Vol.19, No.4, p 369-378, June 1970. 10 p, 2 fig, 2 tab, 6 ref.

Descriptors: *Groundwater movement, *Transmissivity, *Data processing, Hydrologic data, Permeability, Steady flow, Unsteady flow, Drawdown, Water levels, Water table, Water storage, Storage coefficient, Aquifers, Water level fluctuations, Water yield.
Identifiers: Pumping tests, Aquifer tests.

The error involved in finding the coefficients of transmissibility and storage using pumping-test data are briefly discussed. Distance-drawdown data are advocated as generally most suitable for finding the transmissibility. Procedures are based on distance-drawdown analysis with constant storage coefficient and time-drawdown analysis with delayed yield from storage. Anomalies which result from well-known methods of analysis are illustrated by pumping test data. The methods described assume a fully-penetrating pumped well and shallow observation wells, except in the case of a very deep aquifer. A computer is not required. An exact equation, allowing for the vertical velocity-component of the flow and delayed yield from storage, is given.

70-71:02F-028
MATHEMATICAL MODEL OF LEAKY AQUIFER,
Bibby, R., and Sunada, D. K.
Colorado State University, Fort Collins.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, Proc. Paper 8350, p 387-395, 1971. 1 tab, 5 fig, 9 ref, 2 append.

Descriptors: *Aquifers, *Leakage, *Mathematical model, Drainage, Groundwater irrigation, Numerical analysis.
Identifiers: Kiowa-Bijou basin of Colorado.

A description is given for a technique to determine the direction and volume of leakage between a confined aquifer and an overlying unconfined aquifer. The technique involves the numerical modeling of only the unconfined aquifer, so that data are required on only this aquifer. The predicted values of water table elevation obtained from the numerical model are compared to known values. From discrepancies between these values, inferences can be made on the direction and volume of leakage. The results of the application of the technique in the Kiowa-Bijou basin of Colorado are given. Even with poor input data to the model the results obtained on the direction of leakage are good, but the accuracy of the estimate of the volume of leakage depends more on the accuracy of the input data.

70-71:02F-029
NUMERICAL ANALYSIS OF FREE SURFACE SEEPAGE PROBLEMS,
France, P. W., Parekh, C. J., and Taylor, C.
Wales University, Swansea, Wales.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR1, p 165-179, 1971. 12 fig, 16 ref.

Descriptors: Aquifer, Computer, Drainage, Hydrology, Seepage, Wells, Soil mechanics.
Identifiers: Time dependence, Finite element.

The finite element numerical technique is used to effect a solution to linear seepage problems. Particular reference is made to the time dependent movement of a phreatic surface. The flow domain is represented by subdomains composed of isoparametric elements, which permit a close approximation to curved boundaries. The ease of application to seepage through inhomogeneous media is demonstrated during the development of the finite element discretization technique. It is shown that relatively few of the sophisticated isoparametric elements yield solutions to particular flow situations which compare favorably with other numerical and experimental methods for both steady state and time dependent problems. The generality of approach is shown by particular examples, such as flow towards wells and through an earth dam which amplify the versatility of the particular numerical technique used.

70-71:02F-030
WATER STORAGE AND DRAINAGE UNDER A ROW CROP ON A SANDY SOIL,
Black, T. A., Gardner, W. R., and Tanner, C. B.
British Columbia University, Vancouver, Canada, Department of Soil Science.
Agronomy Journal, Vol. 62, No. 1, p 48-51, 1970. 5 fig, 9 ref.

Descriptors: *Drainage, *Evaporation, *Evapotranspiration, Darcy's Law, Root zone.
Identifiers: Soil-water storage, Snap beans, Soil water characteristics.

Drainage from the root zone of snap beans grown on a sandy soil was measured by a lysimeter, and calculated from Darcy's law, and by a hydrologic balance equation. At the end of a 60 day period the Darcy's law calculation gave a 11% higher estimate of the cumulative drainage than the other two methods. Of the 32 cm of precipitation and decrease of 3 cm in water storage from emergence to harvest, evapotranspiration accounted for 17 cm, and drainage for 18 cm. A useful estimate of the drainage from the root zone in sandy soil was obtained from the space averaged capillary conductivity of the soil in which rooting occurred.

70-71:02F-031
ONE-DIMENSIONAL INFILTRATION INTO LAYERED SOILS,
Fok, Yu-Si.
Texas Water Rights Commission, Austin, Texas, Technical Services Division, Basin Hydrology Section.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR2, Proc. Paper 7343, p 121-129, 1970. 2 tab, 1 fig, 2 append, 4 ref.
(See 70-71:02G-057)

70-71:02F-032
NEED FOR ENVELOPE MATERIAL ABOVE DRAINTILE,
Saulmon, R. W.
United States Department of Agriculture, Sidney, Montana.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR4, p 661-663, 1971. 1 fig, 1 append, 3 ref.

Descriptors: Drainage, Tile, Filtration, Filter.
Identifiers: Envelope material.

The fitter or envelope material often placed around draintile lines can serve any or all of three purposes: (1) To provide proper bedding of the tile sections; (2) to act as a filter to prevent the movement of fine sand and silt into the drain; and (3) to provide a medium of increased permeability next to the tile line to increase the rate of flow into the drain. The effect of removal of half of the envelope on the performance of a draintile installation will vary with each drainage situation. Analysis herein is limited to a drainage situation in which the tile line flows less than half full and the upper portion of the envelope remains unsaturated. During a laboratory study, a comparison was obtained of the performance of a draintile installed with a complete envelope to that of one installed with only half of the envelope. The results of this test indicated that elimination of the upper portion of a draintile envelope, which is commonly unsaturated, can cause a decrease in flow rate to the tile.

70-71:02F-033
IRRIGATION INVESTIGATIONS IN OTAGO, NEW ZEALAND: VII. GROUND WATER AND SOIL SALINITY IN THE KUROW-DUNTROON DISTRICT,
Cossens, G. G., and Rickard, D. S.
Invermay Agricultural Research Centre, Mosgiel, Field Research Section, Dept of Agriculture, Private Bag.
New Zealand Journal of Agricultural Research, Vol. 13, No. 2, p 218-224, 1970. 2 tab, 4 ref.

Descriptors: *Ground water, Soil, Irrigation, Chemical analysis.
Identifiers: Kurow-Duntroon district (Otago, New Zealand).

The surface waters of the Kurow-Duntroon irrigation area are of low salinity. Except for a very restricted area the ground water is also of low salinity and is at too great a depth to cause soil salinisation problems as a result of irrigation. Leaching of the few saline areas should be possible with controlled irrigation.

70-71:02F-034
NOTES: HALF-MINUTE COUNTS FOR NEUTRON PROBES,
Rogerson, T. L.
United States Department of Agriculture Forest Service, Harrison, Arkansas.
Soil Science, Vol. 110, No. 5, p 359-360, November 1970. 2 tab, 4 ref.
(See 70-71:02E-005)

70-71:02F-035
AIR PUMP FOR SMALL-DIAMETER PIEZOMETERS,
Trescott, P. C., and Pinder, G. F.
Nova Scotia Department of Mines, Halifax, Nova Scotia.
Groundwater Hydrology, Vol. 8, No. 3, p 10-15, May-June 1970. 8 fig, 5 ref.

Descriptors: *Piezometers, *Water sampling, Aquifer testing, Groundwater.
Identifiers: Air pump, Air compressor.

The engine of a field vehicle can easily be used as an air pump by inserting a commercially manufactured check valve into a spark-plug socket. Small-diameter piezometers can be pumped with compressed air from this source. With sufficient air-line submergence, the air lift method can be used to pump 1-inch diameter piezometers where the pumping lift is less than 70 feet and 1.25-inch diameter piezometers where the pumping lift is less than 50 feet. The maximum pumping lift is a function of the rate at which pressure in the piezometer is increased and the rate at which water flows into the formation with increasing head in the piezometer.

70-71:02F-036
SUMMARY OF PANEL ON CARBON ISOTOPES IN SUBSURFACE HYDROLOGY AND THE ROLE OF PALEOCLIMATES IN THEIR INTERPRETATION,
Bradley, E., Scientific Secretary
Journal of Hydrology, Vol. 11, No. 4, p 439-441, April 1970.

Descriptors: *Hydrology, *Subsurface waters, *Paleoclimatology, Carbon radioisotopes, Groundwater, Groundwater movement.
Identifiers: *Groundwater mapping, *Carbon dating.

A Panel on "Carbon Isotopes in Subsurface Hydrology and the Role of Paleoclimates in their Interpretation" was held from the 16th to the 20th of March, 1970, in Vienna, Austria. Under certain conditions and considered in conjunction with geochemical, stable isotope and related paleoclimatic information, radiocarbon data from water samples are very useful in hydrologic interpretations. They may, for example help distinguish water of different origins. Furthermore, determining an approximate apparent "age" by the carbon-14 method makes it possible to find the rate of groundwater flow between wells along flow lines (or between a definite recharge zone and sampling points some distance down gradient).

70-71:02F-037
NON-LINEAR THERMODYNAMICS OF SOIL-WATER-HEAT SYSTEMS,
Pal, R., and Gupta, M. P.
Haryana Agricultural University, Hissar (Haryana) India.
Journal of Hydrology, Vol. 11, No. 3, p 313-315, March 1970. 8 ref.

Descriptors: *Hydrology, *Soil physics, *Soil water, *Thermodydamics, Soil temperature, Heat transfer.
Identifiers: Soil-water-heat systems.

Evaluation of the second order phenomenological coefficients in soil-water-heat system as suggested by Srivastava and Abrol is examined and discrepancy there-in reported.

70-71:02F-038
ISOTOPIC EXCHANGE STUDIES OF MICRONUTRIENTS IN SOILS,
Lopez, P. L., and Graham, E. R.
Missouri University, Columbia.
Soil Science, Vol. 110, No. 1, p 24-30, July, 1970. 4 tab, 16 ref.
(See 70-71:02K-025)

70-71:02F-039
THE CHEMICAL HISTORY OF SOME SPRING WATERS IN CARBONATE ROCKS,
Jacobson, R. L., and Langmuir, D.
Pennsylvania State University, University Park, Department of Geochemistry and Mineralogy.
Groundwater Hydrology, Vol. 8, No. 3, p 5-9, May-June 1970. 4 fig, 2 tab, 9 ref.

Descriptors: *Water quality, *Spring waters, *Carbonates, Water pollution sources, Salinity, Mineral water, Groundwater movement.
Identifiers: *Residence time.

Insights into the chemical and hydrogeologic history of spring waters in carbonate rocks was gained from a study of the chemical quality of such waters and of the waters which feed the springs. Most of the dissolved solids were added to spring waters during groundwater flow. Dye tracing of groundwater feeding springs in two drainage basins gave residence times of from 2-6 days for subsurface flows of 4000 feet. Specific conductances ranged from 180 to 476 micromhos, with a mean of 347 micromhos.

70-71:02F-040
DETERMINATION OF A WATER TABLE IN A SOIL PROFILE USING THE PLATINUM OXYGEN CATHODE,
West, D. W., and Black, J. D. F.
Horticulture Department of Agriculture, Ferntree Gully, Victoria, Australia.
Soil Science, Vol. 110, No. 2, p 119-123, August 1970. 3 fig, 1 tab, 8 ref.

Descriptors: *Water table, *Groundwater, Soil water, Saturated soil, Soil gases.
Identifiers: Water table determination, Platinum cathode, Oxygen flux.

The techniques of measuring soil oxygen flux with the platinum cathode have been applied to the determination of oxygen deficient, water saturated zones in soil profiles. Measurements were taken at depth intervals through the profile to locate the large change in flux which occurs on moving the electrode from the unsaturated into the saturated soil zone. For most satisfactory use of the technique the transition zone should occur over a narrow depth interval. As the purpose of the technique does not require measurement of the precise oxygen flux, modification of the usual procedure for measuring equilibrium soil oxygen flux is suggested to increase the sensitivity of the determination.

70-71:02F-041
SOIL HYDRAULIC CONDUCTIVITY AND BULK VOLUME CHANGES DURING CYCLIC CALCIUM-SODIUM EXCHANGE,
Waldron, L. J., and Constantin, G. K.
California University, Berkeley.
Soil Science, Vol. 110, No. 2, p 81-85, August 1970. 3 fig, 3 tab, 7 ref.
(See 70-71:02K-027)

70-71:02F-042
RAPID MEASUREMENT OF HYDRAULIC CONDUCTIVITY CHANGES IN SLOWLY PERMEABLE SOILS,
Nightingale, H. I., and Bianchi, W. C.

United States Department of Agriculture, Fresno, California, Agricultural Research Service.
Soil Science, Vol. 110, No. 4, p 221-228, October 1970. 5 fig, 4 tab, 10 ref.

Descriptors: *Hydraulic conductivity, *Saturated flow, Groundwater movement, Permeability, Porus media.
Identifiers: *Hydraulic conductivity measurement, *Slowly permeable soils, Laboratory method.

The strain gage permeameter was described which, along with supporting equipment, provides a laboratory measurement of low saturated conductivity of a confined soil layer. Hydraulic conductivities in the range from above 10^{-2} to 10^{-5} cm/day can be determined in about 2 to 50 minutes, respectively. Values less than 10^{-2} cm/day should be determined with a strip chart millivolt recorder to resolve the falling head-time relationship with acceptable accuracy. The support equipment was designed primarily to study the affect of water quality on the time rate of change in hydraulic conductivity of slowly permeable soil material under a loaded condition.

70-71:02F-043
THE EFFECT OF ELECTROLYTE COMPOSITION ON HYDRAULIC CONDUCTIVITY OF CERTAIN TEXAS SOILS,
Naghshineh-Pour, B., Kunze, G. W., and Carson, C. D.
Ahwaz Agricultural College, Ahwaz, Iran.
Soil Science, Vol. 110, No. 2, p 124-127, August 1970. 5 fig, 1 tab, 13 ref.
(See 70-71:02K-028)

70-71:02F-044
THERMODYNAMICS OF SOIL-WATER SYSTEM,
Pal, R., and Gupta, M. P.
Haryana Agricultural University, Hissar, Haryana, India.
Journal of Hydrology, Vol. 13, No. 3, p 278-280, September 1971. 8 ref.

Descriptors: *Hydrology, *Soil physics, *Soil water, *Thermodynamics, Soil temperature, Heat transfer.
Identifiers: Soil-water-heat systems.

Nonequilibrium thermodynamic theory as applied to soil-water-heat system by Taylor and Cary is examined and discrepancy therein reported.

70-71:02F-045
THE CONCENTRATION OF K, CA, AND MG IN THE SATURATION EXTRACT IN RELATION TO EXCHANGEABLE K, CA, AND MG,
Nemeth, K., Mengel, K., and Grimme, H.
Landwirtschaftliche Forschungsanstalt, Buntehof, Hannover.
Soil Science, Vol. 109, No. 3, p 179-185, March 1970. 5 fig, 1 tab, 15 ref.
(See 70-71:02K-029)

70-71:02F-046
ANION EXCLUSION EFFECTS ON CHLORIDE MOVEMENT IN SOILS,
Thomas, G. W., and Swoboda, A. B.
Kentucky University, Lexington.
Soil Science, Vol. 110, No. 3, p 163-166, September 1970. 5 fig, 1 tab, 9 ref.
(See 70-71:02K-030)

70-71:02F-047
DISSOLUTION OF DICALCIUM PHOSPHATE IN RELATION TO IRON OXIDE CONTENT OF ACID SOILS,

Sree Ramulu, U. S., and Pratt, P. F.
Agricultural College, Coimbatore, Madras, India.
Soil Science, Vol. 109, No. 1, p 35-39, January 1970. 2 fig, 2 tab, 15 ref.
(See 70-71:02K-031)

70-71:02F-048
INFILTRATION INDUCED SOIL INSTABILITIES,
Adrian, D. D.
Massachusetts University, Amherst, Civil Engineering Department.
Groundwater Hydrology, Vol. 8, No. 1, p 29-36, January-February 1970. 6 fig, 7 ref.
(See 70-71:02G-068)

70-71:02F-049
INFLUENCE OF VARIOUS TREATMENTS ON THE DISSOLUTION OF DICALCIUM PHOSPHATE IN SOILS,
Sree Ramulu, U. S., Pratt, P. F.
California University, Riverside.
Soil Science, Vol. 109, No. 3, p 186-189, March 1970. 2 tab, 16 ref.
(See 70-71:02K-032)

70-71:02F-050
FERTILIZERS,
Viets, F. G., Jr.
United States Department of Agriculture, Fort Collins, Colorado, Agricultural Research Service, Northern Plains Branch, Soil and Water Conservation Research Division.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 51-53, March-April 1971. 1 tab, 18 ref.
(See 70-71:05B-032)

70-71:02F-051
A STUDY OF TWO-DIMENSIONAL INFILTRATION,
Fok, Yu-Si.
Hawaii University, Honolulu, Dept of Civil Engineering and Water Resource, Research Center.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 15, p 676-681, May 1970. 2 fig, 2 ref.

Descriptors: *Soil water movement, *Infiltration, *Porous media, Permeability, Soil physics, Soil properties.
Identifiers: Two-dimensional infiltration.

Laboratory studies have been made to correlate the observed two-dimensional infiltration with the observed horizontal and vertical soil moisture movements. The exponents of the infiltration equation may be expressed as the sum of the exponents of the horizontal and vertical soil moisture movement equations. The significance of the infiltration geometry has also been studied. The exponent of the infiltration equation varies with the width and depth of the ditch and the ultimate value of the exponent equals the exponent of the vertical downward soil moisture movement equation.

70-71:02F-052
A MODEL STUDY OF DRAIN ENVELOPES IN A COARSE-SILT BASE MATERIAL,
Lembke, W. D., and Bucks, D. A.
Illinois University, Urbana, Agricultural Engineering Department; and Soil and Water Conservation Laboratory, Phoenix, Arizona.

American Society of Agricultural Engineers, Transactions, Vol. 13, No. 15, p 669-675, May 1970. 7 fig, 2 tab, 8 ref.

Descriptors: *Drainage engineering, *Subsurface drainage, *Tile drainage, Drainage systems, Drainage, Filters.
Identifiers: *Gravel envelopes.

The resistance-network analogue study of a ponded-surface box model of a tile-drain envelope and surrounding soil showed that the model would need to be extremely large in order to develop a stream pattern in the vicinity of the envelope similar to that which would occur in a field situation. The flow system around the drain was modeled by using source tubes to impose an equipotential surface. The model was observed in testing two thicknesses of envelope material. The top corners of the gravel envelope were found to be particularly subject to intrusion by fine particles.

70-71:02F-053
DITCH DRAINAGE OF ANISOTROPIC NONHOMOGENEOUS POROUS MEDIA: A MODEL STUDY,
Rochester, E. W., Jr., and Kriz, G. J.
Auburn University, Auburn, Alabama, Dept of Agricultural Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5, p 626-628, May 1970. 8 fig, 2 ref.

Descriptors: *Porous media, *Saturated flow, *Drainage, Model study, Anisotropy.
Identifiers: *Impermeable boundary, Nonhomogenous.

The critical depth of an impermeable layer below equally spaced parallel drains was determined for a homogeneous and a two-layered isotropic soil. The results were then mapped mathematically to the anisotropic case. The effect of the impermeable layer was determined by observing the rate of fall of the fluid free surface at the midpoint of a Hele-Shaw model. It was found that for a homogeneous isotropic soil the critical depth to the impermeable layer is one-ninth spacing. Conclusions for the two layered system are also presented.

70-71:02F-054
HYDRAULIC CONDUCTIVITY SAMPLING FOR CONFIDENCE,
Dylla, A. S., and Guitjens, J. C.
United States Department of Agriculture, Reno, Nevada, Agricultural Research Service, Nevada Agricultural Experiment Station.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 4, p 485-488, April 1970. 4 fig, 2 tab, 6 ref.

Descriptors: *Groundwater, *Hydraulic conductivity, *Permeability, Darcy's Law, Porous media, Saturated flow, Percolating water, Drainage.
Identifiers: Probability method.

Analyses of hydraulic conductivity measurements in a highly variable soil indicate that hydraulic conductivity sampling should be spatially distributed over the field. A probability method, based on an initial sample, for determining the final sample size required to assure that both the sample mean and the population mean fall within specified confidence length or limits is presented. A nomograph is also presented to facilitate solution of the trail-and-error procedure for determining the required sample size.

70-71:02F-055
THEORY OF CHEMICAL TRANSPORT WITH SIMULTANEOUS SORPTION IN A WATER SATURATED POROUS MEDIUM,
Lindstrom, F. T., and Boersma, L.
Oregon State University, Corvallis, Dept of Agricultural Chemistry and Soils.
Soil Science, Vol. 110, No. 1, p 1-7, July 1970. 7 tab, 16 ref.

Descriptors: *Mathematical models, *Porous media, *Flow, Flow system, Chemicals, Saturated.
Identifiers: Chemical transport.

Three models for a general transport problem of chemical in a water saturated porous medium have been presented. It is difficult to assign experimentally verified values to all the parameters involved. It is, therefore, not possible to suggest which model is the most correct one to describe the movement of chemicals in a water saturated porous medium. The experimental evidence available seems to indicate that the Freudlich type isotherm is sufficient for most transport-adsorption experiments. But we have shown that it is also possible to adequately describe the sink effect with two other, mathematically completely different models.

70-71:02F-056
A COMPARISON OF METHODS FOR THE DETERMINATION OF SOIL ORGANIC PHOSPHOROUS,
Williams, J. D. H., Syers, J. K., Walker, T. W., and Rex, R. W.
Lincoln College, Canterbury, New Zealand; and California University, Riverside.
Soil Science, Vol. 110, No. 1, p 13-17, July 1970. 1 fig, 2 tab, 9 ref.
(See 70-71:02K-034)

70-71:02F-057
MOVEMENT OF SALT AND WATER NEAR CRYSTALLINE SALT IN RELATIVELY DRY SOIL,
Scotter, D. R., and Raats, P. A. C.
Wisconsin University, Madison; and United States Department of Agriculture.
Soil Science, Vol. 109, No. 3, p 170-178, March 1970. 9 fig, 17 ref.
(See 70-71:02K-035)

70-71:02F-058
FIELD MEASUREMENT OF HYDRAULIC CONDUCTIVITY ABOVE A WATER TABLE WITH AIR ENTRY PERMEAMETER,
Aldabagh, A. S. Y., and Beer, C. E.
Iowa State University, Ames, Agricultural Engineering Department.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 1, p 29-31, January 1971. 3 tab, 12 ref.

Descriptors: *Soil physics, *Hydraulic conductivity, *Darcey's Law, Groundwater movement, Porous media, Permeability, Infiltration, Drainage.
Identifiers: Air-entry permeameter.

The air-entry permeameter consists of an infiltration cylinder with an air tight lid. A water source and a vacuum gage are connected to the lid. After a wet front has been established, the soil suction is measured. Several pieces of data were obtained and an equation developed from which the hydraulic conductivity can be calculated. The results obtained compared favorably with laboratory data for the same soil. Advantages of the method include: The method is relatively fast, portability of the equipment, hydraulic conductivity is measured in situ, and the presence of a water table is not required.

70-71:02F-059
SALINITY AND WATER USE,
Talsma, T., and Philip, J. R.
The MacMillan Press, London, England. 1971. 296 p, 2 append.
(See 70-71:01B-002)

70-71:02F-060
THE GEOCHEMISTRY OF UNDERGROUND WATER,
Swaine, D. J., and Schneider, J. L.

Division of Mineralogy, Sydney, Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971. Canberra, Australia, p 3-23. 7 fig, 2 tab, 45 ref.

Descriptors: *Groundwater, *Geochemistry, *Water quality, Water chemistry, Soil chemistry, Soil water, Groundwater resources, Soil analysis, Geophysics.

This paper discusses various geochemical aspects of underground waters, starting with the origin of the waters and effects occurring during diagenesis and compaction. Other important factors, dealt with in detail, are the composition of water and the nature of the aquifer, the modification of composition by membrane filtration effects, evaporation, sulphate reduction and ion exchange. The means of studying changes in chemical composition are also outlined. The results of investigations in Chad, Cap Vert Peninsula, North Cameroon and the Gironde Estuary are discussed. The importance of correct use of data is stressed. In particular, hydrogeochemical maps are most helpful in the assessment of water use and in monitoring of pollution. Reference is made to the relevance of hydrogeochemical investigations to other fields, such as ore genesis.

70-71:02F-061
TRANSPORT OF SALTS IN UNSATURATED AND SATURATED SOILS,
Peck, A. J.
Division of Soils, Wembley, Western Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 109-123. 1 fig, 67 ref.

Descriptors: *Porous media, Flow, *Groundwater, Salinity, Saturated flow, Unsaturated flow, Diffusion, Convection, Soil chemistry, Mathematical models.

At very slow rates of solution flow, molecular diffusion is the dominant transport mechanism, but diffusion in solution is a very slow process. The presence of the solid and gaseous phases in soils, and exchange or adsorption of solutes result in even lower diffusion coefficients in soils than in bulk solution. In the vicinity of plant roots, molecular diffusion may be the dominant transport process at somewhat greater rates of convection due to the possible association of a relatively high concentration gradient and low nutrient concentration. In general, molecular diffusion interacts with the convection of solutions and each process contributes to the dispersion of solutes. Thus inert solutes are mostly transported at the average velocity of the solution, but there is a superimposed dispersion of solutes about the mean position at any instant. Mathematically this dispersion may be treated as a diffusion-like process. Solutes which experience adsorption or exchange on soil surfaces travel at less than the average pore velocity. Ion exchange theories can be useful in interpreting the transport in these conditions, but there is at present, no generally satisfactory theory.

70-71:02F-062
GROUNDWATER PROBLEMS OF THE INTERACTION OF SALINE AND FRESH WATER,
Wooding, R. A.
Division of Environmental Mechanics, Canberra, Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 125-139. 55 ref.
(See 70-71:01B-004)

SECTION VII

WATER CYCLE

WATER IN SOILS (Group 02G)

70-71:02G-001
EFFECTS OF IRRIGATION WATER TEMPERATURE ON SOIL TEMPERATURE,
Wierenga, P. J., Hagan, Robert M., and Gregory, E. J.
New Mexico State University, University Park, Dept of Agronomy.
Agronomy Journal, Vol. 63, No. 1, p 33-36, 1971. 3 fig, 1 tab, 15 ref.

Descriptors: *Soil temperature, *Water cooling, Irrigation, Evaporation, Conduction.

Identifiers: Cooling, Heat, Probe, Thermocouple, Water.

Soil temperatures were measured in fields irrigated with normal and cold water and in unirrigated soil. Temperatures were measured with probes made of thermocouple wire enclosed in 3 mm O.D. stainless-steel tubing. Errors in temperature measurement were on the order of 0.1°C or less. The effects of irrigation water temperature on soil temperature were small and of short duration. Differences in soil temperature resulting from irrigation with water of 27°C and 14°C lasted for less than 24 hours at 5 cm and 10 cm and for 60 hours at 30 cm. Irrigated soil temperatures were significantly reduced by evaporative cooling from the soil surface after irrigation in mid-April, though not in mid-February.

70-71:02G-002
APPLICATION OF AN EXTRACTION-TERM MODEL TO THE STUDY OF MOISTURE FLOW TO PLANT ROOTS,
Molz, F. J., and Remson, Irwin.
Auburn University, Alabama, Dept of Civil Engineering.
Agronomy Journal, Vol. 63, No. 1, p 72-77, 1971. 16 fig, 1 tab, 9 ref.

Descriptors: *Extraction, *Soil-water-plant relationship, *Model study, Root system, Flow system, Transpiration.

Identifiers: Depth, Moisture, Plant root, Roots, Extraction-term model, Douglas-Jones predictor-corrector method, Darcian flow.

A one-dimensional extraction-term model is used to simulate the moisture flow and removal process in the vicinity of plant roots. The dependence of model results on root depth and soil type are investigated. Moisture contents, root moisture absorption rates and soil-moisture fluxes are computed and discussed for several hypothetical root systems in a sandy soil and in a clay soils. The model is solved numerically with a procedure based on the Douglas-Jones predictor-corrector method. Moisture extraction by the roots from soil in their immediate vicinity is the dominant process, with Darcian flow in the root zone playing a smaller but often significant role. Extraction-term models are versatile and seem able to describe many of the phenomena associated with moisture removal by the roots of transpiring plants.

70-71:02G-003
INFLUENCE OF NO-TILLAGE ON SOIL MOISTURE,
Blevins, R. L., Cook, Doyle, Phillips, S. H., and Phillips, R. E.
Kentucky University, Lexington, Dept of Agronomy.
Agronomy Journal, Vol. 63, No. 4, p 593-596, 1971. 5 fig, 2 tab, 10 ref.

Descriptors: *Moisture content, *Tillage, *Corn, Crop Response, Soil.

Identifiers: Corn-M, Moisture, Soil, Storage, Tillage, Yield, Zea-Mays-M.

Field studies were conducted to compare the effect of non-tillage versus conventional tillage corn (Zea mays L.) production on soil moisutre. The studies were made on a Donerail silt loam in 1968 and 1969 and on a Maury silt loam in 1970. Soil moisture was measured periodically at various depths in the soil profile during the growing seasons. No tillage treatments had higher volumetric moisture contents to a depth of 60 cm during most of the growing season. The greatest differences occurred in the upper 0 to 8-cm depth. Beyond a depth of 60 cm, systems of tillage had little influence on soil moisture during the growing seasons. Soil moisture curves indicate different water withdrawal patterns under the 2 contrasting methods of tillage. The decrease in evaporation and the greater ability to store moisture under no-tillage produces a greater water reserve. This can often carry the crop through periods of short-term drought and avoid the development of detrimental moisture stresses in the plant. The more efficient use of soil moisture by no-tillage is reflected in higher corn yields. This study further substantiates the effectiveness of no-tillage systems of corn production on well to moderately well drained silt loam soils in Kentucky and other regions with similar climatic regimes.

70-71:02G-004
SOIL SALINITY EFFECTS ON ABSORPTION OF NITROGEN, PHOSPHORUS, AND PROTEIN SYNTHESIS BY COASTAL BERMUDAGRASS
Langdale, G. W., and Thomas, J. R.
Agricultural Research Service, Weslaco, Texas, Soil and Water Conservation Research Division.
Agronomy Journal, Vol. 63, No. 5, p 708-711, 1971. 4 fig, 1 tab, 18 ref.

Descriptors: *Salinity, *Absorption, *Nitrogen, *Phosphorus, Fertilizer, Soil.

Identifiers: Bermuda, Coastal, Cynodon-Dactylon-M, Grass-M, Synthesis, Soil Salinity, Protein synthesis.

The interaction of artificially salinized soil and N-P fertilization on dry-matter production and protein synthesis of coastal bermudagrass (Cynodon dactylon (L) Pers.) was studied in a greenhouse environment. Saline solutions were prepared in concentration multiples with the same ionic ratios as the available irrigation water to develop four treatments with electrical conductivities (EC) of 0, 4.8, 9.6, and 14.4 mmhos/cm. After saline-water equilibration of a Brennan fine sandy loam soil (Typic Haplustalif), fertilizer treatments were applied in a factorial arrangement with N rates of 0, 67, 133, and 200 mg/kg of soil and P rates of 0, 20, 40, and 60 mg/kg of soil. No response was obtained from P fertilization. Significant interactions occurred for both dry-matter and protein-N yields with soil salinity and N supply treatments. Soil salinities of 5.3 and 6.6 mmhos/cm yielded the most dry matter and protein N, respectively, in the presence of N fertilizer. Reduction in soluble N (nonprotein) occurred at the most efficient levels of protein-N synthesis. Although N requirements decreased as soil salinity increased, N fertilization offset effects of salinity up to 9.6 mmhos/cm. Dry-matter and protein syntheses were seriously restricted at the 14.4 mmhos/cm salinity level; however, salinity levels did not restrict N absorption by coastal bermudagrass.

70-71:02G-005
SPRINKLER INTENSITY AND SOIL TILTH,
Keller, Jack.
Utah State University, Logan, Agricultural and Irrigation Engineering Dept, and Utah Agricultural Experiment Station, Logan.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 1, p 118-125, January-February 1970. 10 fig, 4 tab, 16 ref.

Descriptors: *Sprinkler irrigation, *Rates of application, *Soil structure, *Soil mechanics, *Soil texture, Soil strength, Settlement (Structural), Bulk density, Mohr envelope, Time, Drainage, Soil water movement, Soil moisture, Moisture tension, Wetting, Drops (Fluids), Equations, Aggregates, Soil aggregates.
Identifiers: *Tilth, *Soil tilth.

Rate and duration of irrigation application have a definite effect on tilth of medium- and fine-textured soils. When combined with long duration and/or poor soil drainage, high application rates can destroy soil tilth. Experimental results showed that the total amount of surface settling of each soil was a function of rate of application and initial bulk density of the sample. It was also found that amount of settling for a given sample and initial density was inversely proportional to minimum soil moisture tension during irrigation. A soil strength theory was proposed in which strength of loosely packed unstable soil to withstand consolidation forces is related to soil moisture tension during irrigation.

70-71:02G-006
AUGER-HOLE HYDRAULIC CONDUCTIVITY: FIRST VERSUS SECOND TEST,
Dylla, A. S., and Michener, D. W.
Agricultural Research Service, Reno, Nevada, Soil and Water Conservation Research Division.
American Society of Agricultural Engineers Transactions, Vol. 14, No. 3, p 582-583, May-June 1971. 2 fig, 6 ref.

Descriptors: *Hydraulic conductivity, *Transmissivity, *Aquifer testing, *Boreholes, *Pumping, Water yield, Calibrations, Soil water movement, Water table, Drawdown, *Nevada.
Identifiers: *Reno (Nevada).

Hydraulic conductivity measurements were made from over 300 auger holes on a Truckee series soil at the University of Nevada Agricultural Experiment Station Main Farm at Reno. At least two tests were made from each auger hole. With paired hydraulic conductivity measurements (first and second) for each auger hole, the statistical Students t-test for the paired data was used to determine if there was any real difference between the means of the first and second measurements. There was no significant difference between the first and second hydraulic conductivity measurements of an auger hole. Observed or apparent individual difference between measurements at a hole was the result of some random physical occurrence that caused a change in the hydraulic conductivity measured. About half the time, the first measurement was larger. This indicated that it should not be necessary to pump or bail the hole a few times before conductivity measurements to allow it to 'cleanse.'

70-71:02G-007
AN APPROXIMATE METHOD FOR DEFINING THE HYDRAULIC CONDUCTIVITY-PRESSURE POTENTIAL RELATIONSHIP FOR SOILS,
Skaggs, R. W., Monke, E. J., and Huggins, L. F.
Purdue University, Lafayette, Indiana.
American Society of Agricultural Engineers Transactions, Vol. 14, No. 1, p 130-133, 1971. 8 fig, 16 ref.

Descriptors: *Soil water movement, *Mathematical studies, *Hydraulic conductivity, *Soil properties, *Methodology, Infiltration, Flow rates, Pressure head, Equations.
Identifiers: Unsaturated soils.

Quantification of infiltration of water into soil is one of a broader class of problems involving the movement of water in unsaturated soil. The relationship between the hydraulic conductivity K, and the pressure head, h, or the water content, is necessary for solving the governing equation. Conventional techniques for measuring K(h) are both difficult and time consuming. An approximate method for defining the conductivity functions of unsaturated soil shows that the measurements required in the proposed method can be made a relatively short time and, unlike conventional techniques, there is a good possibility that this method can be adapted for in-place, field determination of K(h). An evaluation of the method utilizing soil property data from the literature for four separate soils is presented and discussed.

70-71:02G-008
ESTIMATING SOIL PERMEABILITY RATES,
Horn, M. E.
Harza Engineering Company, Chicago, Illinois, Land Resources Division.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol.97, No.L R-2, Paper 8169, p 263-274, June 1971. 3 fig, 6 tab, 8 ref.

Descriptors: *Permeability, *Soil water movement, *Seepage, *Estimating, *Particle size, Clays, Silts, Sands, Hydraulic conductivity, Soil chemical properties, Soil texture, Sampling, Soil mechanics.
Identifiers: Permeability estimation.

A guide for estimating soil permeability rates was developed based on mean soil particle diameters. The method takes into account the wide ranges within commonly used soil textural classes and the influence of soil chemical properties, clay mineralogy, and other related factors affecting soil permeability. Curves plotted on a log-log graph of soil texture versus permeability establish graphically the general limits of permeability rates for natural soils. Considerations in selecting working curves that relate soil texture and permeability rates for local conditions are also discussed. Permeability rates are estimated in planning and designing irrigation and drainage systems when obtaining actual field measurements is difficult and impractical, or the data available are scant and misleading.

70-71:02G-009
STEADY DRAINAGE OF LAYERED SOILS: II, NOMOGRAPHS,
Toksoz, Sadik, and Kirkham, Don.
Iowa State University of Science and Technology, Ames. Water Resources Research Institute.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol.97, No.IR-1, Paper 7986, p 19-37, March 1971. 19 p, 17 fig, 2 tab, 9 ref, append.

Descriptors: *Soil water movement, *Subsurface drainage, *Groundwater, *Steady flow, Agricultural engineering, Flow nets, Seepage, Soils, Soil water, Water table, Mathematical studies, Equations.
Identifiers; *Underground drains, Layered soils, Nomographs.

The drain spacing equations for the two-layered and three-layered soils are given. A set of 16 figures containing 29 nomographs may be used for easy calculation of drain spacings in two-layered soils. Drain spacings calculated by using Dagan's equation for the two-layered soils agree with the spacings calculated from the nomographs.

70-71:02G-010
STEADY DRAINAGE OF LAYERED SOILS: I, THEORY,
Toksoz, Sadik, and Kirkham, Don.
Iowa State University of Science and Technology, Ames. Water Resources Research Institute.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR-1, Paper 7985, p 1-18, March 1971. 18 p, 4 fig, 5 ref, append.

Descriptors: *Soil water movement, *Subsurface drainage, *Groundwater, *Steady flow, *Agricultural engineering, Flow nets, Seepage, Soils, Soil water,

Theoretical analysis, Mathematical studies, Water table.
Identifiers: *Underground drains, Layered soils.

The stream and potential functions for the steady drainage of two-layered and three-layered soils were derived. Two sets of flow nets are given for each case. From the derivations for the two-layered and three-layered soils, steady drainage problems for soils with more than three layers may be solved.

70-71:02G-011
MOVEMENT OF SALTS IN PONDED ANISOTROPIC SOILS,
Ortiz, Jaime, and Luthin, James N.
California University, Davis. Dept of Water Science and Engineering.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol.96, No.IR3, Paper 7530, p 257-264, September 1970.
8 fig, 5 fig, 6 ref, append.

Descriptors: *Leaching, *Saline soils, *Saline water-freshwater interfaces, *Tile drainage, Soil water movement, Groundwater movement, Ion transport, Mass transfer, Drainage engineering, Subsurface drainage, Tile drains, Computer programs.
Identifiers: *Ponded anisotropic soils.

A method of determining the displacement front of an interface between saline and fresh water to subsurface drains under ponded conditions is extended to anisotropic soils. A computer program written in FORTRAN IV allows determination of the position of the displacement front at different times when point values of the stream and potential function are available. The results presented can be applied to any other system geometrically similar to the system considered. Leaching in the region halfway between drains will be better for an anisotropic soil than for an isotropic one.

70-71:02G-012
INFILTRATION EQUATIONS FROM RATE-OF-ADVANCE DATA,
Norum, Donald I., and Gray, Don M.
Saskatchewan University, Saskatoon.
Proceedings of the American Society of Civil Engineers, Journal of the Irrigation Drainage Division, Vol.96, No.IR2, p 111-119, June 1970. 9 p, 2 fig, 13 ref, 2 append.

Descriptors: *Infiltration, Irrigation, *Infiltrometers, Groundwater movement. Permeability, Seepage, Coefficients, *Border irrigation, Irrigation water, *Equations, Canal seepage.
Identifiers: *Infiltration rate, *Irrigation advance, Flow depth.

A method was developed for determining infiltration equations from rate-of-advance data using solutions of the Lewis-Milne border irrigation equation, plotted in dimensionless form on logarithmic paper. Rate-of-advance data were superimposed on the solutions and the coefficients determined from the matching factors for the best fit curve. The basic assumption was that the depth of flow on the surface is constant. If sufficient data are available, the technique can be extended to determine the average depth of flow on the surface.

70-71:02G-013
ANALYTICAL TREATMENT OF TWO-PHASE INFILTRATION,
Brustkern, Richard L., and Morel-Seytoux, Hubert J.
Colorado State University, Fort Collins, Dept of Civil Engineering.
American Society of Civil Engineers Proceedings, Journal of the Hydraulics Division, Vol.96, No.HY12, Paper 7743, p 2535-2548, December 1970. 14 p, 10 fig, 8 ref, append.

Descriptors: *Unsaturated flow, *Computer programs, *Numerical analysis, *Infiltration, Soil moisture movement, Porous media, Capillary action.

Identifiers: *Multiphase flow.

An approximate analytical treatment for the problem of one-dimensional infiltration into a homogeneous porous medium is presented. Movement of both the air phase and the water phase is considered. The procedure assumes that capillary pressure can be neglected in the saturation equation, whereas it is retained in an integral equation for the unknown total flow. The two equations are solved in a step-wise manner to yield the saturation profile, and the infiltration rate at any time. Infiltration rate curves are obtained for a number of situations involving different boundary or initial conditions or both. Infiltration rate predictions are in good agreement with those predicted by a finite difference solution. This is quite promising in view of the fact that the computer costs are an order of magnitude less than by the finite difference technique.

70-71:02G-014
OVERLAND FLOW ON AN INFILTRATING SURFACE,
Smith, R. E., and Woolhiser, D. A.
Agricultural Research Service, Tucson, Arizona, Southwest Watershed Research Center.
Water Resources Research, Vol.7, No.4, p 899-913, August 1971. 13 fig, 18 ref, append.

Descriptors: *Rainfall-runoff relationships, *Mathematical models, *Overland flow, *Infiltration, *Numerical analysis, Runoff, Parametric hydrology, Hydrograph analysis, Recession curves, Unsteady flow, Runoff forecasting, Hydraulic models.
Identifiers: Hastings (Nebraska).

The partial differential equation for vertical, one-phase, unsaturated moisture flow in soils is employed as a mathematical model for infiltration rate. Solution of this equation for the rainfall-ponding upper boundary condition is proposed as a sensitive means to describe infiltration rate as a dependent upper boundary condition. A nonlinear Crank-Nicholson implicit finite difference scheme is used to develop a solution to this equation that predicts infiltration under realistic upper boundary and soil matrix conditions. The kinematic wave approximation to the equations of unsteady overland flow on cascaded planes is solved by a second order explicit difference scheme. The difference equations of infiltration and overland flow are then combined into a model for a simple watershed that employs computational logic so that boundary conditions match at the soil surface. The mathematical model is tested by comparison with data from a 40-foot laboratory soil flume fitted with a rainfall simulator and with data from the USDA Agricultural Research Service experimental watershed at Hastings, Nebraska. Good agreement is obtained between measured and predicted hydrographs, although there are some differences in recession lengths. The results indicate that a theoretically based model can be used to describe simple watershed response when appropriate physical parameters can be obtained.

70-71:02G-015
RESONANCE - CAPACITANCE SOIL MOISTURE METER,
Kuraz, V., Kutilek, M., and Kaspar, I.
Technical University of Prague (Czechoslovakia).
Soil Science, Vol.110, No.4, p 278-279, 1970. 2 fig, 3 ref.

Descriptors: *Soil moisture meter, *Moisture content, Soil water, Measurement, Meter, Soil.

Identifiers: Capacitance, Resonance, Moisture.

The resonance frequency, f, of a LC circuit, f -- (1/(2 II)) (sq. rt of (1/LC)) is used in the construction of a resonance-capacitance soil moisture meter;

L is the inductance of a constant value, C the capacitance. The dielectric of the capacitor is formed by the glass of the tube and by the soil inserted in the tube. For measuring, a grid deep meter is used. The passive L-C circuit is freely inductionally bound with the active circuit of the grid deep meter. If the passive circuit is in resonance with the oscillator of the grid deep meter, the maximum decrease of energy will occur in the oscillator circuit. The passive circuit is not influenced by the measuring circuit as happens for the other capacitance methods. The moisture content in loess and silty sand was measured without disturbing the soil body. The calibration curves of the dependence of the soil moisture upon the resonance frequency are represented either by a straight line or by a curve of a very low curvature. The sensitivity is roughly the same in all the range of the moisture content and the maximum error is about 1.5 percent of moisture.

70-71:02G-016
HYSTERESIS OF PORE WATER IN GRANULAR POROUS BODIES,
Poulovassilis, A.
Agricultural Research Council, Cambridge (England).
Soil Sciences, Vol. 109, No. 1, p 5-12, January 1970. 8 p, 10 fig, 1 tab, 5 ref.

Descriptors: *Hysteresis, *Porous materials, *Porous media, Wetting, *Granular materials, Sands, Hydraulic conductivity, Moisture content, Drying, Soil science, Soil engineering, Forecasting, Laboratory tests.
Identifiers: Suction, *Pore water, Soil columns, Soil suction.

Experimental results concerning the hysteresis behavior of granular porous bodies are compared with the predictions of the independent domain concept. A dynamic method is described for the direct determination of the relationships between moisture content and suction and moisture content and hydraulic conductivity on long vertical columns. Some experimental results concerning the hysteresis of the hydraulic conductivity are reported. To achieve the desired results, it was necessary to devise a method of stabilizing the geometry of a granular porous body, over long periods and over many reversals of wetting and drying, more generally applicable than in sintering. The method adopted was to work with deep columns of material and to stablize the geometry by overburden pressure.

70-71:02G-017
SOIL TEMPERATURE PROFILES DURING INFILTRATION AND REDISTRIBUTION OF COOL AND WARM IRRIGATION WATER,
Wierenga, P. J., Hagan, R. M., and Nielsen, D. R.
California University, Davis.
Water Resources Research, Vol. 6, No. 1, p 230-238, February 1970. 9 p, 6 fig, 2 tab, 14 ref.

Descriptors: *Soil temperature, *Infiltration, *Irrigation water, Mass transfer, Percolation, Heat transfer, Conduction, Convection, Evaporation, Soil-water-plant relationships.
Identifiers: Warm water irrigation.

Soil temperatures were measured in field profiles irrigated with cool and warm water and also measured in nonirrigated soil. Differences in soil temperature between plots after irrigation with cool (4.1 deg C) and warm (21.6 deg C) water, persisted longer at the lower soil depths. The time required after an irrigation for these differences to decline to less than 1 deg C was 14 hours at the 1-cm depth, 36 hours at the 10-cm depth, and 42 hours at the 20-cm depth. A numerical procedure developed for predicting changes in soil temperature through the soil profile after irrigation with cool and warm water gave good agreement between observed and calculated values in the sub-soil but not in the surface soil. During infiltration heat transfer occurred mainly by mass movement, whereas after 10 hours soil heat transfer below 10 cm occurred mainly by conduction.

70-71:02G-018
A FUNCTIONAL ITERATION TECHNIQUE FOR SOLVING THE RICHARDS EQUATION APPLIED TO TWO-DIMENSIONAL INFILTRATION PROBLEMS,
Brutsaert, W. F.
New Mexico Institute of Mining and Technology, Socorro, Department of Geoscience.
Water Resources Research, Vol. 7, No. 6, p 1583-1596, December 1971. 6 fig, 3 tab, 17 ref, append.

Descriptors: *Mathematical studies, *Infiltration, *Groundwater movement, *Mathematical models, *Computer programs, Simulation analysis, Numerical analysis, Soil water movement, Unsaturated flow, Hydraulic conductivity.

In a solution of nonlinear parabolic partial differential equations, such as the Richards equation, classical implicit schemes often oscillate and fail to converge. A fully implicit scheme was developed along with a functional iteration method for solving the system of nonlinear difference equations. Newton's iteration technique is mathematically the best of all functional iteration methods because of its quadratic convergence. The Richards equation, Newton-linearized with respect to relative permeability and saturation as functions of capillary pressure, is particularly aided by this new approach for problems in which saturations vary rapidly with time (infiltration fronts, cone of depression near a well bore, and so forth). Although the computing time is almost twice as long for a time step with Newton's iteration scheme, the smaller time truncation than that of classical implicit schemes and the stability in cases in which classical schemes are unstable permit the use of much larger steps. To demonstrate the method, heterogeneous (layered) soil systems are used to simulate sharp infiltration fronts caused by ponding at the soil surface.

70-71:02G-019
DYNAMIC SIMULATION OF VERTICAL INFILTRATION INTO UNSATURATED SOILS,
Bhuiyan, S. I., Hiler, E. A., van Bavel, C. H. M., and Aston, A. R.
Texas A and M University, College Station, Department of Agricultural Engineering.
Available from the National Technical Information Service as PB-204 709, $3.00 in paper copy, $0.95 in microfiche. Water Resources Institute Research Report (1971). 23 p, 8 fig, 15 ref.

Descriptors: *Soil water movement, *Infiltration, *Unsaturated flow, *Soil properties, *Computer models, Darcy's law, Systems analysis, Mathematical models, Numerical analysis, Transmissivity, Diffusivity, Porous media, Input-output analysis.
Identifiers: *Unsaturated soils, Vertical infiltration.

A dynamic simulation language (S/360CSMP) was used to develop a computer model which simulated vertical infiltration of water into unsaturated soil. The modeling concept consisted primarily of dividing the soil into a large number of layers of equal thickness. The net flux of water through each layer at any particular time was established using the principles of conservation of mass and Darcy's law. The ensuing water content was then calculated by integrating the net flux utilizing the fourth order Runge-Kutta method with suitable error criteria. The cumulative infiltration was calculated from the instantaneous infiltration rates using the same integration technique. Water content profiles with time were obtained for three different soils: Yolo light clay, Adelanto loam and Pachappa loam. The infiltration rate and cumulative amount were also calculated with time giving a complete picture of the water intake characteristics of the soil.

70-71:02G-020
APPLICATION OF THERMOCOUPLE PSYCHROMETERS TO SOIL WATER TRANSPORT,
Enfield, C. G., and Hsieh, J. J. C.
Battelle Memorial Institution, Richland, Washington, Pacific Northwest Labs.
Water Resources Research, Vol. 7, No. 5, p 1349-1353, October 1971. 4 fig, 1 tab, 9 ref.

Descriptors: *Soil water movement, *Soil moisture meters, *Water temperature, *Hydraulic conductivity, *Hydraulic gradient, Instrumentation, Infiltration, Groundwater recharge, Evapotranspiration.
Identifiers: Termocouple psychrometer.

The energy status (potential) of water can be used to calculate water flux. Thus, field measurement of water potential is superior to conventional gravimetric soil moisture content measurements for dynamic soil water studies and is useful for steady state analysis of soil water transport. Soil thermocouple psychrometers give sufficiently sensitive, in situ measurements of water potential to apply energy concepts to dynamic soil water movement. Thus the soil thermocouple psychtometer can be used to obtain soil water potential information needed to determine the direction of water flow and the magnitude of the driving force. This technique is not limited to studies of the penetration of rainfall in the arid region but also has application in evapotranspiration studies, and might be adaptable to such studies as groundwater hazards of sanitary land fills.

70-71:02G-021
PHYSICAL SIMULATION OF INFILTRATION EQUATIONS,
Lin, W., and Gray, D. M.
Saskatchewan University, Saskatoon, Division of Hydrology.
Water Resources Research, Vol.7, No.5, p 1234-1240, October 1971. 5 fig, 1 tab, 13 ref.

Descriptors: *Infiltration, *Mathematical models, *Hydraulic models, *Soil water movement, *Percolation, Numerical analysis, Porosity, Fluid mechanics, Laminar flow, Hydraulic conductivity, Capillary action, Simulation analysis.

Laminar (capillary) flow method may be used for synthesizing the infiltration process on physical hydrologic models. The equations defining laminar flow in capillary tubes and between parallel plates were derived for several different geometric configurations representing horizontal, vertically downward, vertically upward, and radial flow. The theoretical equations for the different configurations are analogous in functional form to the theoretical and empirical infiltration equations used to define the time variation in the infiltration rate of a soil. The results from several tests conducted on capillary tubes were in close agreement with those obtained from the theoretical equations.

70-71:02G-022
SIMULTANEOUS SOLUTE AND WATER TRANSFER FOR AN UNSATURATED SOIL,
Warrick, A. W., Biggar, J. W., and Nielsen, D. R.
Arizona University, Tucson, Dept of Agricultural Chemistry and Soils.
Water Resources Research, Vol.7, No.5, p 1216-1225, October 1971. 11 fig, 13 ref.

Descriptors: *Unsaturated flow, *Soil water movement, *Ion transport, *Aqueous solutions, *Water chemistry, Path of pollutants, Sorption, Absorption, Mathematical models, Numerical analysis, Salts, Infiltration, Percolation, Mass transfer, Chlorides.
Identifiers: Solute transfer.

The simultaneous transfer of solute and water during infiltration was studied both in the field and numerically. An apparent diffusion coefficient of about 0.07 sq cm/min provided maximum solute concentration values over a 17-hour period. The advance of a solute front with irrigation water is nearly independent of the initial soil moisture content but highly dependent on the moisture content maintained at the soil surface during infiltration.

70-71:02G-023
SOIL-WATER HYSTERESIS: THE DOMAIN THEORY EXTENDED TO PORE INTERACTION CONSITIONS,
Topp, G. C.
Department of Agriculture, Ottawa (Ontario). Soil Research Institute.
Soil Science Society of America Proceedings, Vol.35, No.2, p 219-225, March-April 1971. 7 p, 10 fig, 13 ref.

Descriptors: *Wetting, *Soil water movement, *Hysteresis, Porous media, Infiltration, Percolation.
Identifiers: Independent domain theory.

Some inadequacies of the independent domain theory of hysteresis were overcome by modifying an extension to the theory to include two types of pore interactions. In the independent domain theory only the shapes of the pores determined the draining and filling characteristics of each pore. In this extension to the theory, the draining and filling of each pore depends on the state of neighboring pores as well as the pore geometry. The ratios of changes in water content of the soil during drying and rewetting over a given pressure head range were used to determine the importance of pore interactions and to separate the two types of pore blockage. Primary scanning curve data for porous materials ranging from glass beads to clay loam soil showed that pore blockage against air-entry during drying of a soil near saturation and pore blockage against water-entry during rewetting of a relatively dry soil were the two major types of pore interactions. The degree of pore blockage appeared to be dependent only on the water content of the soil.

70-71:02G-024
HYSTERESIS DURING INFILTRATION AND REDISTRIBUTION IN A SOIL COLUMN AT DIFFERENT INITIAL WATER CONTENTS,
Vachaud, Georges, Thony, Jean-Louis.
Grenoble University, (France). Dept of Hydrology.
Grant 69-01-666 from General Delegation of Scientific and Technical Research, Paris. Water Resources Research, Vol. 7, No.1, p 111-127, February 1971. 17 p, 15 fig, 34 ref.

Descriptors: *Hysteresis, *Infiltration, *Evaporation, *Percolation, *Soil water movement, Unsaturated flow, Hydraulic conductivity, Soil physical properties, Saturated flow, Permeameters, Recharge, Soil moisture meters, Nuclear moisture meters, Tensiometers, Gamma rays, Moisture content.
Identifiers: Soil water redistribution.

Experimental results dealing with flow processes involving hysteresis effects in the suction-water content relationship were obtained on a vertical column of soil submitted to the following successive controlled flow conditions: (1) redistribution of water following a constant head infiltration in an initially air-dried column, (2) constant head infiltration followed by redistribution, and (3) constant flux infiltration followed by control evaporation and redistribution. Water contents were measured by using gamma ray attenuation, and water suctions were obtained simultaneously from 10 pressure transducers distributed along the soil column, each one being connected to a tensiometer. All the data were punched on tape and treated with a computer. Examination of the changes of water content and water suction at a given depth yielded precise information on hysteretic behavior. The scanning curves for a single reversal can be defined uniquely with reference to the transition water content, the independent domain theory appears to be inadequate for describing soil water hysteresis completely, and hydraulic conductivity can be considered practically unique.

70-71:02G-025
A MODEL OF SURFACE CRUSTING AND INFILTRATION OF BARE SOILS,
Seginer, Ido, and Morin, Joseph.
Technion - Israel Institute of Technology, Haifa; and Ministry of Agriculture.
Water Resources Research, Vol.6, No.2, p 629-633, April 1970. 5 p, 6 ref.

Descriptors: *Infiltration, *Impact (Rainfall), *Soil compaction, *Permeability, *Mathematical models, Soil structure, Soil moisture, Soil water movement, Soil surfaces, Surface sealing.
Identifiers: Soil surface crusting.

An infiltration equation was derived on the assumption that a drop upon impact with the soil compacts a small area. The size of this area is characteristic of the drop and the soil properties. Extensions of this model can treat spectrums of drops and variations of rainfall characteristics with time. The model applies to initially saturated homogeneous soil columns and leads to the conclusion that the reduction of infiltration capacity is not directly related to time but rather to the number of drops that hit the surface. The effect of the depth of the soil column on the final infiltration capacity is such that the deeper it is, the higher the final infiltration capacity, approaching a limit, which depends on the properties of the crust, not of the subsoil. It is suggested that comparisons between infiltration experiments in columns be made on the basis of the intrinsic value of the limiting infiltration capacity.

70-71:02G-026
COMPARISON OF SOLUTIONS OF A NONLINEAR DIFFUSION EQUATION,
Brutsaert, Wilfried, and Weisman, Richard N.
Cornell University, Ithaca, New York.
Water Resources Research, Vol.6, No.2, p 642-644, April 1970. 3 p, 1 fig, 1 tab, 7 ref.

Descriptors: *Diffusion, *Equations, *Mathematical studies, Mathematical models, Infiltration, Percolation, Numerical analysis.
Identifiers: Nonlinear diffusion.

Four solutions of a general nonlinear diffusion equation are given. A numerical analysis serves as reference for one series solution and for two more simple approximate solutions. The accuracy of the methods is discussed and presented graphically; the results of the numerical analysis are given in tabular form. It was found that the usefulness of the two approximate solutions lies in their mathematical simplicity and the accuracy with which they describe infiltration.

70-71:02G-027
AN EXPERIMENTAL INVESTIGATION OF RUNOFF PRODUCTION IN PERMEABLE SOILS,
Dunne, Thomas, and Black, Richard D.
McGill University, Montreal (Quebec).
Water Resources Research, Vol.6, No.2, p 478-490, April 1970. 13 p, 10 fig, 4 tab, 12 ref.

Descriptors: *Rainfall-runoff relationships, *On-site tests, *Model studies, *Subsurface runoff, *Overland flow, Infiltration, Groundwater movement, Soil water movement, Simulated rainfall, Antecedent precipitation.
Identifiers: Experimental watersheds.

In an area of low intensity rainfall and permeable soils, three hillside plots were instrumented for a study of runoff-producing mechanisms. Runoff from the plots was measured at the ground surface, the base of the root zone, and in the zone of perennial groundwater seepage. Data on soil moisture, water-table elevation, and piezometric head were collected during both natural and artificial storms. When the infiltration capacity of the soil exceeded the rainfall intensities, overland flow did not occur. Although soils and topography were those generally thought to be conducive to subsurface stormflow, the runoff produced by this mechanism was too small, too late, and too insensitive to fluctuations of rainfall intensity to add significantly to stormflow in the channel at the base of the hillside. When the water table rose to the surface of the ground, overland flow was generated on small areas of the hillside. Only when this overland flow occurred were significant amounts of stormflow contributed to the channel by the hillside. The return periods of storms that would produce such overland flow were found to be very large.

70-71:02G-028
A MOVING-BOUNDARY MODEL OF A ONE-DIMENSIONAL SATURATED-UNSATURATED, TRANSIENT POROUS-FLOW SYSTEM,
Hornberger, George M., and Remson, Irwin.
Stanford University, California.
Typescript, 1969. 23 p, 9 fig, 15 ref.

Descriptors: *Mathematical models, *Flow, *Porous media, *Saturated flow, *Unsaturated flow, Drainage, Water.
Identifiers: *Taylor series method, Finite-difference method.

A moving-boundary model was proposed for one-dimensional transient flow of water through a porous media of which part was saturated and part unsaturated. The model was based upon a theory which implies a discontinuous propagation of pore pressure at the saturated-unsaturated interface. The moving-boundary model was used to study a gravity drainage problem. Two numerical procedures were developed to solve the problem, an approximate Taylor series method and a finite-difference method. The validity of the methods was appraised by comparing the results with experimental data given by Watson. The Taylor series method was limited in applicability because of a need for accurate determination of derivations of hydraulic conductivity and of moisture content with respect to pressure head. The finite-difference solution was very efficient because only changes in the unsaturated region were computed and the need for iteration was obviated.

70-71:02G-029
A MOVING BOUNDARY MODEL OF A ONE-DIMENSIONAL SATURATED-UNSATURATED, TRANSIENT POROUS FLOW SYSTEM,
Hornberger, George M., and Remson, Irwin.
Stanford University, California.
Water Resources Research, Vol. 6, No. 3, p 898-905, June 1970. 8 p, 9 fig, 15 ref.

Descriptors: *Groundwater movement, *Soil water movement, *Saturated flow, *Unsaturated flow, *Mathematical models, Unsteady flow, Porous media, Digital computers, Water level fluctuations, Infiltration, Recharge.
Identifiers: Finite difference analysis.

A moving boundary model is proposed for one-dimensional transient flow of water through a porous medium of which part is saturated and part is unsaturated. The model is based upon a theory that implies a discontinous propagation of pore pressure at the saturated-unsaturated interface. The moving boundary model is used to study a gravity drainage problem. Two numerical procedures are developed to solve the problem, an approximate Taylor series method and a finite difference method. The validity of the methods was appraised by comparing the results with experimental data. The Taylor series method is limited in applicability because of a need for accurate determination of derivatives of hydraulic conductivity and of moisture content respecting pressure head. The finite difference solution is very efficient because only changes in the unsaturated region are computed and the need for iteration is obviated.

70-71:02G-030
FINITE ELEMENT METHOD OF ANALYZING STEADY SEEPAGE WITH A FREE SURFACE,
Neuman, Shlomo P., and Witherspoon, Paul A.
California University, Berkeley.
Water Resources Research, Vol. 6, No. 3, p 889-897, June 1970. 9 p, 8 fig, 25 ref.

Descriptors: *Seepage, *Groundwater movement, *Free surfaces, *Dams,

*Mathematical models, Digital computers, Aquifers, Water table, Leakage, Percolation, Anisotropy, Porous media.
Identifiers: Finite element analysis.

A new iterative approach to steady seepage of groundwater with a free surface was developed using the finite element method. This approach eliminates a number of difficulties that were inherent in the iterative procedures previously used to solve this problem, and rapid convergence is now assured in all cases. The method is applicable to heterogeneous porous media with complex geometric boundaries and arbitrary degrees of anisotropy. It can handle problems where the free surface is discontinuous and where portions of the free surface are vertical or near vertical. In addition, infiltration or evapotranspiration at the free surface can be handled with ease. Several examples are included to demonstrate the power of this new approach and to show how it can apply to a wider variety of free surface problems than has been possible before.

70-71:02G-031
POST-IRRIGATION MOVEMENT OF SOIL WATER: 1. REDISTRIBUTION,
Gardner, W. R., Hillel, D., and Benyamini, Y.
Wisconsin University, Madison.
Water Resources Research, Vol. 6, No. 3, p 851-861, June 1970. 11 p, 7 fig, 19 ref.

Descriptors: *Soil water movement, *Irrigation water, Percolation, Unsaturated flow, Hysteresis, Equations, Laboratory tests, Wetting, Nuclear moisture meters, Permeameters, Instrumentation.
Identifiers: Soil water redistribution.

Water content measurements by gamma-ray attenuation in soil columns were made during redistribution following irrigation. Approximate solutions of the unsaturated flow equation are derived that describe the water content above the initial wetting front as a function of time. For times sufficiently large, these solutions reduce to a frequently used empirical expression, using constants related to the capillary conductivity and soil water diffusivity.

70-71:02G-032
POST-IRRIGATION MOVEMENT OF SOIL WATER: 2. SIMULTANEOUS REDISTRIBUTION AND EVAPORATION,
Gardner, W. R., Hillel, D., and Benyamini, Y.
Wisconsin University, Madison.
Water Resources Research, Vol. 6, No. 4, p 1148-1153, August 1970. 6 p, 6 fig, 9 ref.

Descriptors: *Soil water movement, *Evaporation, *Percolation, *Irrigation water, *Evaporation control, Water conservation, Nuclear moisture meters, Soil moisture meters, Laboratory tests, Evapotranspiration.
Identifiers: Soil water redistribution.

Water content measurements by gamma-ray attenuation were made on soil columns during simultaneous redistribution and evaporation following irrigation. Redistribution is shown to reduce evaporation, in some cases appreciably. For a deep irrigation the redistribution proceeds at a rate that is relatively independent of the evaporation process, as has been predicted from numerical solutions of the flow equation. Expressions are derived for obtaining an estimate of amount of reduction in evaporation due to redistribution when the redistribution rate is known.

70-71:02G-033
DETERMINATION OF SOIL DENSITY AND WATER CONTENT BY FAST NEUTRONS AND GAMMA RAYS,
Corey, J. C., Boulogne, A. R., and Horton, J. H.
Du Pont de Nemours (E. I.) and Company, Aiken, South Carolina.

Water Resources Research, Vol. 6, No. 1, p 223-229, February 1970. 7 p, 6 fig, 5 tab, 18 ref.

Descriptors: *Nuclear moisture meters, *Gamma rays, *Soil moisture meters, *Instrumentation, Soil water, Bulk density, Moisture content.
Identifiers: Gamma attenuation meters, Neutron attenuation meters.

Sequential measurements of gamma and fast neutron attenuation were used for nondestructive determination of both soil density and water content of soil samples. Soils containing known amounts of water were packed into 22.5-cm diameter cylinders to a depth of 9 cm. Measurements were made of attenuation of fast neutrons and attenuation of gamma rays in a collimated beam. The attenuation was used to calculate the soil density and water content of these samples. The mean difference between the calculated and known water contents was 0.006 g/cc with a standard deviation of 0.010 g/cc; the mean difference for soil density was 0.010 g/cc with a standard deviation of 0.017 g/cc. Calculations based only on counting statistics show that an attenuation method using a combination of gamma and fast neutrons is better than a method using 2 gamma energies.

70-71:02G-034
SOME EFFECTS OF SURFACE COVER GEOMETRY ON INFILTRATION RATE,
Koon, J. L., Hendrick, J. G., and Hermanson, R. E.
Auburn University, Alabama.
Water Resources Research, Vol. 6, No. 1, p 246-253, February 1970. 8 p, 9 fig, 11 ref.

Descriptors: *Infiltration, *Permeability, *Laboratory tests, *Simulated rainfall, Model studies, Puddling, Ponding, Hydraulic models, Vegetation effects, Surface-groundwater relationships, Rainfall disposition, Impact (Rainfall).
Identifiers: Surface permeability, Soil cover effects.

Infiltration into the soil is regulated in part by sealing of the soil surface by raindrop impact. Soil surfaces protected from such impact maintained higher rates of infiltration than exposed soil surfaces. It was hypothesized that the cover particles protected the covered portion of the soil and prevented the reaction of raindrop impact on the soil state. The soil under the cover particles remained in the original state in which infiltration could occur. However, since the cover particles in this study were impervious, infiltration could not occur on the covered area but would occur along the available perimeter of the cover particles. Water would then move in both vertical and lateral directions. The effective lateral distance that the water moved after entry was defined as the effective width. To evaluate the effects of soil surface cover on the infiltration rate of soils exposed to raindrop impact, simulated rainfall was applied at a constant rate to one soil type in small plots with free drainage, and square and rectangular cover particles of varying sizes and percentages were used as surface cover.

70-71:02G-035
NUMERICAL SIMULATION TECHNIQUE FOR VERTICAL DRAINAGE FROM A SOIL COLUMN,
Kastanek, F.
Institute for Land and Water Management Research, Wageningen (Netherlands).
Journal of Hydrology, Vol.14, No.3/4, p 213-232, December 1971. 18 fig, 2 tab, 4 ref.

Descriptors: *Soil water movement, *Infiltration, *Simulation analysis, *Numerical analysis, *Computer programs, Hydraulic conductivity, Percolation, Mathematical models, Unsaturated flow, Saturated flow, Unsteady flow, Capillary conductivity.

A numerical method for simulating the time-dependent drainage from a vertical soil column offers the possibility of computing the discharge as well as the hydraulic gradient for any desired time, if the capillary conductivity and the moisture content of the soil are given as functions of suction. The soil column is modeled by thin layers, each having different capillary conductivity and water content. The number of layers, their individual thickness and their position is time dependent and their determination is inherent in the calculation procedure. For each layer a water balance is made for small time intervals. The required calculation procedure is programmed in FORTRAN-Subset for IBM 1130.

70-71:02G-036
SOME PROPERTIES OF FLOWS IN UNSATURATED SOILS WITH AN EXPONENTIAL DEPENDENCE OF THE HYDRAULIC CONDUCTIVITY UPON THE PRESSURE HEAD,
Raats, P. A. C.
Johns Hopkins University, Baltimore, Maryland.
Journal of Hydrology, Vol.14, No.2, p 129-138, November 1971. 1 fig, 21 ref.

Descriptors: *Soil water movement, *Unsaturated flow, *Hydraulic conductivity, *Pressure head, Darcy's law, Hydraulic models, Percolation, Mathematical studies.

A systematic development of the consequences of an exponential dependence of the hydraulic conductivity upon the pressure head is presented. Alternative expressions for the flux are discussed in detail. For steady flows, partial differential equations in terms of the matric flux potential, the pressure head, and the total head are derived. For steady, plane and axially symmetric flows, partial differential equations for the stream function are given. A theoretical basis for the construction of viscous flow analogs for steady, plane and axially symmetric flows is also presented.

70-71:02G-037
COMPARISON OF METHODS FOR CALCULATING VERTICAL DRAINAGE AND INFILTRATION FOR SOILS,
Whisler, Frank D., and Bouwer, Herman.
Agricultural Research Service, Phoenix, Arizona.
Journal of Hydrology, Vol.10, No.1, p 1-19, January 1970. 19 p, 13 fig, 1 tab, 20 ref.

Descriptors: *Drainage, *Infiltration, *Soils, Capillary conductivity, Soil water movement, Numerical analysis, Numerical method, Methodology, Equations, Porous media, Capillary tubes, Groundwater flow, Unsaturated flow, Hydraulic conductivity, Saturated flow, Bibliographies, Drainage engineering, Moisture uptake, Theoretical analysis.
Identifiers: *Comparative studies, Infiltration rate, Soil columns, Water absorption tests, Permeability tests.

The Youngs, Gardner, Ligon, and numerical analysis techniques for calculating the amounts of one-dimensional, vertical drainage from soil are discussed and compared with each other and with observed data. The same was done with the Green and Ampt, Philip, and numerical analysis methods for calculating the amounts of infiltration into soil profiles. The numerical analysis methods gave the best agreement with the observations, but required considerable input data, and the calculation procedure was not simple. The Youngs drainage equation and the Green and Ampt infiltration equation were the easiest to use, giving reasonably accurate results that are probably sufficient for most field problems.

70-71:02G-038
THE GRAVIMETRIC METHOD OF SOIL MOISTURE DETERMINATION, PART I - A STUDY OF EQUIPMENT, AND METHODOLOGICAL PROBLEMS,
Reynolds, S. G.
South Pacific Regional College of Tropical Agriculture, Alafua (Western Samoa).

Journal of Hydrology, Vol. 11, No. 3, p 258-273, September 1970. 16 p, 1 fig, 6 tab, 28 ref.

Descriptors: *Gravimetry, *Soil moisture, *Sampling, *Laboratory tests, Gravimetric analysis, Soil moisture meters, Moisture content, On-site tests, Analytical techniques, Cores, Soil analysis, Test procedures.
Identifiers: Soil moisture analysis.

The type of sampling device, whether a screw or coring auger, is shown to influence soil moisture determinations. Moisture losses after storage of samples in glass tubes or aluminum foil for periods up to 7 days are shown to be negligible. Aluminum foil is recommended as a very inexpensive and efficient container. As the rate and length of drying needed for different soils is quite variable, preliminary investigations should be undertaken to establish the times after which negligible losses occur for further periods of drying. In most field studies samples of 50-100 g of soil are adequate; larger samples of 500 g require much longer periods of drying but give similar results. Methodological problems discussed include the site destruction caused by the gravimetric method and the fact that the method itself accounts for some of the variability found in soil moisture distribution, and possibly for supposedly significant changes in soil moisture content in time and space.

70-71:02G-039
THE GRAVIMETRIC METHOD OF SOIL MOISTURE DETERMINATION, PART II - TYPICAL REQUIRED SAMPLE SIZES AND METHODS OF REDUCING VARIABILITY,
Reynolds, S. G.
South Pacific Regional College of Tropical Agriculture, Alafua (Western Saoma).
Journal of Hydrology, Vol. 11, No. 3, p 274-287, September 1970. 14 p, 1 fig, 5 tab, 24 ref.

Descriptors: *Gravimetry, *Sampling, *Soil moisture, Laboratory tests, Gravimetric analysis, Soil moisture meters, Moisture content, Analytical techniques, Cores, Soil analysis, Test procedures.
Identifiers: Soil moisture analysis.

The variability of soil moisture in the 0-8 cm horizon was studied over a range of soil types. Typical sample sizes required to estimate the true mean within variability limits of 10%, 5%, and 2% are discussed. The magnitude of variability is shown to vary greatly from area to area, depending in particular upon the stoniness and nature of the soil, and the type and extent of the vegetation cover. Three methods which might reduce sample size are the use of the gravimetric volume basis method instead of the weight basis method, removal of surface vegetation, and removal of stones and rhizomes from samples.

70-71:02G-040
THE GRAVIMETRIC METHOD OF SOIL MOISTURE DETERMINATION, PART III - AN EXAMINATION OF FACTORS INFLUENCING SOIL MOISTURE VARIABILITY,
Reynolds, S. G.
South Pacific Regional College of Tropical Agriculture, Alafua (Western Samoa).
Journal of Hydrology, Vol. 11, No. 3, p 288-300, September 1970. 13 p, 4 fig, 4 tab.

Descriptors: *Soil moisture, *Vegetation effects, *Variability, Sampling, Rainfall, Solar radiation, On-site tests, Climates, Seasonal, Heat budget, Evapotranspiration, Moisture content, Retention, Root zone, Slopes, Rainfall, Weather, Soil physical properties.
Identifiers: Soil moisture variability.

The influence of various environmental factors on soil moisture variability in the 0-8 cm horizon is examined. The investigation of the influence of vegetation types revealed at least three tentative variability groups (in order of increasing variability) corresponding to areas of recent cultivation, areas of permanent or ley grass, and predominantly uncultivated moor or heathland areas. The dynamic nature of seasonal variability changes are illustrated and correlations established with the amounts of rainfall and insolation in the week preceding sample collection, and the degree of moisture saturation at the time of sampling. Required sample size was directly related to mean moisture content, or the degree of moisture saturation, and the amount of insolation. It is suggested therefore that a decrease in soil moisture content is associated with a decrease in the variance of sample means, and an increase in moisture content is associated with an increase in variance.

70-71:02G-041
SOIL-WATER SAMPLING USING PAN AND DEEP PRESSURE-VACUUM LYSIMETERS,
Parizek, Richard R., and Lane, Burke E.
Pennsylvania State University, University Park, Mineral Conservation Section; and Water and Air Resources Commission, Dover, Delaware.
Journal of Hydrology, Vol 11, No 1, p 1-21, July 1970. 21 p, 8 fig, 1 tab, 14 ref.

Descriptors: *Lysimeters, *Soil water, *Sampling, Monitoring, Irrigation water, Soil water movement, Percolation, Infiltration, Water balance, Pennsylvania, Instrumentation, Leaching, Path of pollutants, Landfills, Water quality.
Identifiers: Suction lysimeters.

Two soil-water sampling devices and success achieved in obtaining soil water on a routine basis at depths of 1 to 36 feet below land surface are described. In one facility, metal pans with copper spounts are driven into the wall of an open trench to intercept gravitational water to a depth of 17 feet. From 4 to 6 inches of water are irrigated adjacent to the trench on a weekly basis. The deep trench lysimeter provides gravitational water samples on a routine basis when waters are artificially applied to the site but failed to yield samples during the growing season in the absence of irrigation under Pennsylvania's climate. A modified version of a commercially available lysimeter can extract soil water under tension from depths in excess of 50 feet. This improved soil-water sampler has been named a pressure-vacuum lysimeter or 'suction lysimeter'. One or more lysimeters may be installed in a 6-inch diameter drill hole. The ceramic tip is embedded in a pulverized silica deposit to insure hydraulic continuity with the soil-water reservoir. When sufficient soil-moisture is available 500 to 970 mls of water may be obtained on a weekly basis. During prolonged dry periods, no samples can be collected when soil water has been depleted around the ceramic point. This may be 4 to 8 weeks after pan lysimeters fail to yield water samples.

70-71:02G-042
RELIABILITY OF SALINITY SENSORS FOR THE MANAGEMENT OF SOIL SALINITY,
Oster, J. D., and Willardson, L. S.
Agricultural Research Service, Riverside, California, Soil and Water Conservation Research Division.
Agronomy Journal, Vol. 63, No. 5, p 695-698, 1971. 5 fig, 2 tab, 9 ref.

Descriptors: *Salinity meters, *Instrumentation, *Sensors, *Reliability, Salinity, Soil management, Performance.

Identifiers: California, Conductivity, Electrical, Infiltration, Irrigation, Management, Soil, Surface, Topography.

Laboratory-constructed and commercial salinity sensors were evaluated for stability of calibration and accuracy of measurement of soil salinity. Of the commercial sensors 85% were stable and performed satisfactorily for at least 1.5 yr with an estimated accuracy of PLUS OR MINUS 0.6 mmho cm-1. Laboratory-constructed sensors were accurate to PLUS OR MINUS 1 mmho cm-1. Commercial sensors were used to monitor soil salinity in a field in the Imperial Valley, California, demonstrating their value for salinity control. The salinity data revealed differences in water infiltration caused by surface topography and the disturbance of soil during the installation of the sensor.

70-71:02G-043

ESTIMATING SOIL MOISTURE DEPLETION FROM CLIMATE, CROP AND SOIL DATA,

Jensen, M. E., Wright, J. L., and Pratt, B. J.
Agricultural Research Service, Kimberly, Idaho, Snake River Research Center.
American Society of Agricultural Engineers Transactions, Vol. 14, No. 5, p 954-959, September-October 1971. 2 fig, 33 ref.

Descriptors: *Irrigation programs, *Computer programs, *Soil moisture, *Irrigation efficiency, *Water requirements, Soil-water-plant relationships, Water management (Applied), Evapotranspiration.
Identifiers: Irrigation scheduling.

One of the greatest potential applications of evapotranspiration technology is in the management of irrigation farms. User-oriented methodology was developed to provide additional information to the irrigation farm manager. The procedure is based on estimating soil moisture depletion from climate, soil and crop data. Estimates of soil moisture depletion are provided for each field for each day of the growing season. Estimates of daily depletions of soil moisture within 10 percent or possibly 15 percent, which usually results in better accuracy over 10- to 20-day periods, are adequate. As a result, the timing of an irrigation will be within 1 day with 10-day frequencies or 2 to 3 days for 20- to 30-day frequencies.

70-71:02G-044

COMPARISON OF EMPIRICAL RELATIONSHIPS BETWEEN PRESSURE HEAD AND HYDRAULIC CONDUCTIVITY AND SOME OBSERVATIONS ON RADIALLY SYMMETRIC FLOW,

Raats, P. A. C., and Gradner, W. R.
Agricultural Research Service, Madison, Wisconsin.
Water Resources Research, Vol. 7, No. 4, p 921-928, August 1971. 6 fig, 1 tab, 20 ref.

Descriptors: *Soil water movement, *Hydraulic conductivity, *Pressure head, *Steady flow, Mathematical studies, Darcys law, Unsaturated flow, Soil physical properties, Saturated flow.
Identifiers: *Matric flux potential, *Partially saturated flow.

It is shown that the critical pressure head used by Bouwer is equal to the difference in matric flux potential at pressure heads zero and minus infinity, divided by the hydraulic conductivity at pressure head zero. The critical pressure head and the saturated hydraulic conductivity are used to define dimensionless pressure head, hydraulic conductivity, and matric flux potential. For six empirical relationships between pressure head and hydraulic conductivity, the associated matric flux potential and critical pressure head are evaluated. The plots of the dimensionless hydraulic conductivity and matric flux potential versus pressure head provide a clear basis for comparing the six models. A discussion of steady radially symmetric flow illustrates matric flux potential and the critical pressure head in flow problems. Expressions are obtained for the steady flux, the maximum steady flux, and the change in steady flux as a function of changes in pressure head at two points. One-dimensional, cylindrically symmetric, and radially symmetric flows are discussed as special cases. The results for the radially symmetric case suggest a new method for in situ determination of the hydraulic conductivity as a function of the pressure head.

70-71:02G-045

WATERSHED PHYSICS: MODEL OF THE SOIL MOISTURE CHARACTERISTIC,

Rogowski, A. S.
Agricultural Research Service, Beltsville, Maryland.
Water Resources Research, Vol. 7, No. 6, p 1575-1582, December 1971. 5 fig, 2 tab, 20 ref.

Descriptors: *Soil water movement, *Infiltration, Soil moisture, Hydraulic conductivity, Estimating, Soil physics.
Identifiers: Watershed physics.

Reasonable estimates of the soil moisture characteristic can be obtained when a reliable curve is not available. Moisture content and pressure at air entry and at 15 bars constitute the required input parameters. The parameters are easily determined or can be readily obtained from published data. Applicability of the model is tested on graded sand and eight soils.

70-71:02G-046
INFLUENCE OF HYDRAULIC PROPERTIES OF SOIL ON PRE-GERMINATION WATER ABSORPTION BY RAPESEED (BRASSICA NAPUS),
Shaykewich, C. F., and Williams, John.
Manitoba University, Winnipeg, Department of Soil Science.
Agronomy Journal, Vol. 63, No. 3, p 454-457, 1971. 3 fig, 4 tab, 12 ref.

Descriptors: *Absorption, *Seeds, Hydraulic conductivity, Germination.
Identifiers: Adsorption, Brassica-Napus-D, Hydraulic, Pre, Rape-D, Soil.

In all seed densities and geometries, water absorption rate was reduced with each decrease in water potential. Hydraulic conductivity had an important influence on the water adsorption process. Soil water potential at which soil hydraulic conductivity became important was dependent upon seed density and geometry and was associated with hydraulic conductivity-water content relation of the seed.

70-71:02G-047
RELEASE OF NITROGEN FROM SULFUR-COATED UREA IN FLOODED SOIL,
Giordana, P. M., and Mortvedt, J. J.
National Fertilizer Development Center, Muscle Shoals, Alabama, Soils and Fertilizer Research Branch.
Agronomy Journal, Vol. 62, No. 5, p 612-614, 1970. 1 tab, 4 fig, 6 ref.

Descriptors: *Nitrogen, *Biological uptake, Soil moisture, Rice.
Identifiers: Soil pH, Nitrogen release, Phosphorus placement, Slow-release N fertilizer, Urea, Rice (Oryza sativa L.).

Laboratory and greenhouse experiments were conducted to investigate the release of N in Mountview soil from sulfur-coated urea (SCU) and the subsequent uptake of N by rice (Oryza sativa L. var. 'Nato'). The rate of N release was much greater in moist than in flooded soil. Granules of SCU became coated with FeS after 2 weeks in flooded soil. When the flooded soil was dried to about field capacity, oxidation of the FeS coatings appeared to seal the granules so that very little N was released. In general, the release of N was slightly greater from SCU applied to limited soils fertilized with P. Dry matter production and uptake of N by rice from SCU was similar to that from uncoated urea when both N sources were incubated in moist soil for at least 2 weeks prior to planting and flooding. Urea applied to the soil immediately before flooding was also effective, but SCU was not.

70-71:02G-048
DRAINAGE OF SOIL PROFILES,
Brooks, R. H., Ng, Benedict, Corey, G. L., and Corey, A. T.
Oregon State University, Corvallis, Agricultural Engineering Department.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, Proc. Paper 8389, p 455-467, 1971. 9 fig, 13 ref, 2 append.

Descriptors: *Capillary pressure, *Similitude, *Water content, Discharge, Soil properties, Drainage, Field capacity.
Identifiers: Brooks-Corey approximation. Diffusion theory, Finite difference theory.

The scaled approximations of Brooks and Corey for water content versus capillary pressure and capillary conductivity versus water content were used to obtain a scaled diffusion function that was dependent only upon the pore-size distribution index, λ. A predictor-corrector finite difference scheme was used to obtain numerical solutions for the scaled differential equation for drainage from vertical soil columns. Results of several numerical solutions were presented for two soil profiles and for two greatly different pore-size distributions. The effects of soil hydraulic properties upon drainage were discussed and used to interpret the term field capacity. Experimental data obtained by several independent investigators were compared with theoretical solutions of discharge as a function of time using the Brooks-Corey approximations. The comparisons between experiment and theory were reasonable and some explanations for lack of agreement were presented.

70-71:02G-049
PHYSICS OF DESATURATION IN POROUS MATERIALS,
White, N. F., Duke, H. R., Sunada, D. K., and Corey, A. T.
Texaco Research Laboratories, Bellaire, Texas.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR2, Proc. Paper 7376, p 165-191, 1970. 2 tab, 17 fig, 15 ref, 3 append.

Descriptors: *Drainage, *Pore pressures, *Porous media, Irrigation, Laboratory tests, Saturation.
Identifiers: Desaturation.

Previous investigations of the hydraulic properties of porous materials have been primarily empirical, i.e., correlations have been based upon experimental data. A physical description of the desaturation process in porous media is developed by analyzing both discrete and continuous desaturation mechanisms. The desaturation process is characterized by three distinct phases: the boundary-effect zone, the transition zone (primary and secondary), and the residual desaturation zone. Mathematical relationships are developed to relate saturation to capillary pressure which corresponds to a characteristic dimension of the medium.

70-71:02G-050
IRRIGATION INVESTIGATIONS IN OTAGO, NEW ZEALAND VI. PHYSICAL PROPERTIES OF SOILS OF THE KUROW DISTRICT,
Cossens, G. G., and Rickard, D. S.
Field Research Section, Mosgiel, New Zealand, Department of Agriculture, Invermay Agricultural Research Centre, Private Bag.
New Zealand Journal of Agricultural Research, Vol. 13, No. 2, p 209-217, 1970. 5 tab, 1 fig, 10 ref.

Descriptors: *Soil moisture, *Soil properties, Climate, Geology, Topography.
Identifiers: Kurow district (Otago, New Zealand).

The yellow-grey earths of the Kurow-Duntroon area have a higher percentage of fine particles and organic carbon and are deeper than soils of the same group in the Ida Valley, the Arrow Basin, the Upper Clutha Valley, and the Maniototo Plains. Because of the high 15-bar retention value, the available moisture (2.55 in) in the top 12 in of the Kurow-Duntroon soils is not particularly high. Over the soil profile, however, the greater depth of soil means that the total available moisutre is higher than that found in previous studies on soils of similar groups. Low macroporosities indicate that over-irrigation may lead to waterlogging of some soils.

70-71:02G-051
SOIL WATER REGIME OF AN ARID GRASSLAND (ERAGROSTIS OPODA BENTH.) COMMUNITY IN CENTRAL AUSTRALIA,
Winkworth, R. E.
Rangelands Research Unit, Commonwealth Scientific and Industrial Research Organization, Canberra, A.C.T. (Australia).

Agricultural Meteorology, Vol. 7, No. 5, p 387-399, 1970. 2 tab, 4 fig, 10 ref.

Descriptors: Soil moisture, Soil profile, Evapotranspiration, Models.
Identifiers: Central Australia, Arid vegetation, Soil water regime.

Precipitation and soil moisture contents through the profile of a red earth soil supporting an arid tussock grassland were recorded for two years near Alice Springs, N.T., Australia. There were six significant periods of soil water recharge, followed by renewed growth of the grassland and withdrawal of soil moisture from the whole profile to very low contents equivalent to an average soil water potential of -120 bar. The low minimum water contents were relatively stable through all dry periods. Water stored in the whole soil profile at contents exceeding the minimum values was calculated and progressive changes in storage during the drying cycles were used to calculate evapotranspiration rates. Average rates ranged from 2.1 mm/day to 0.8 mm/day. The water balance of this community showed that over the whole period about 52% of rainfall entered soil storage, ca. 28% was lost to run-off and 20% was directly evaporated. Plant growth was not measured and hence, the observed variation in peak evapotranspiration rates cannot be explained adequately. The lack of information on the relationship of evapotranspiration rates to plant cover in the arid zone is a serious handicap to the development of computerized water balance models which have important practical significance for estimating forage production on the broad expanses of Australian rangelands.

70-71:02G-052
VARIABLES AFFECTING A-VALUES AS A MEASURE OF SOIL NITROGEN AVAILABILITY,
Broadbent, F. E.
California University, Davis.
Soil Science, Vol. 110, No. 1, p 19-23, July 1970. 3 fig, 4 tab, 15 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, *Nitrogen, Nitrification, Radio isotopes.
Identifiers: *Soil fertility, *Nitrogen availability, *Isotopic tracers, Soil nitrogen, Applied nitrogen, Priming effect.

Tests were performed to determine the accuracy with which A-values predict nitrogen availability. The A-value is defined as the quantity of a given plant nutrient in the soil which is equivalent in availability to that of the same nutrient added as fertilizer. It was noted that values for ammonium nitrogen were higher than for nitrate at corresponding levels of application. Also, the magnitude of the A-value measured in a particular soil will be influenced by rate of nitrification. Data, presented by other authors, was also analysed.

70-71:02G-053
CHARACTERIZING SOIL AERATION UNDER CHANGING SOIL MOISTURE CONDITIONS FOR BEAN GROWTH,
Dasberg, S., and Bakker, J. W.
Volcani Institute of Agricultural Research, Bet-Dagan, Israel.
Agronomy Journal, Vol. 62, No. 6, p 689-692, 1970. 2 tab, 4 fig, 16 ref.

Descriptors: *Aeration, *Soil moisture, Beans, Yield, Irrigation effects, Root development.
Identifiers: Air porosity, Oxygen concentration of soil air, Oxygen diffusion rate, Redox potential.

An attempt was made to evaluate different soil aeration indices as related to plant growth during fluctuations in soil moisture content. Beans (Phaseolus vulgaris var. 'Dubbele Witte') were grown in soil at different aeration conditions obtained by changing bulk density (1.30 and 1.33 g cm^{-3}), irrigation frequencies (3 to 11 days between irrigations), and O_2 concentrations at the soil surface (11% vs 21%). Frequent measurements were taken of O_2 and CO_2 concentrations of the soil air, oxygen diffusion rate (ODR), and redox potential and a continuous record was kept of soil air content by pot weighings. Vegetative growth and dry matter production were affected strongly by bulk density and irrigation frequency (yields ranged 4 to 16 g dry matter per plant). Total root production was hardly influenced, but the depth of root penetration was affected strongly by these aeration treatments. Lowering the O_2 concentration at the soil surface from 21% to 11% had no significant effect on plant growth. Comparing the measured aeration indices (O_2 concentration, ODR, and air content), the mean daily air content gave the best correlation with plant growth ($r = 0.82$). A continuous record of soil air content seems a good index for evaluating aeration under changing soil moisture conditions.

70-71:02G-054

YIELD OF GRAIN LEGUMES AS AFFECTED BY IRRIGATION AND FERTILIZER REGIMES,
Horner, G. M., and Mojtehedi, M.
Agricultural Research Service, United States Department of Agriculture; and
Tehran University, Tehran, Iran, College of Agriculture.
Agronomy Journal, Vol. 62, No. 4, p 449-450, 1970. 4 ref.

Descriptors: *Fertilizer, *Yield, *Moisture stress, Irrigation soil moisture, Legumes, Nitrogen, Phosphorus.

Chickpeas, cowpeas, and dry beans were grown under different soil moisture levels with split plot treatments of no fertilizer, N, P, and NP. Irrigations were given when 1/3, 2/3, and approximately all of the available water in the root zone was depleted. These moisture stresses were applied during different stages of plant growth. High moisture stress reduced grain yields 18 to 26% below the maximum values. This yield depression was most pronounced when the moisture stress occurred during bloom and early maturity. Yields for the medium and high moisture levels were statistically equal. Response to phosphorus fertilization varied with the field sites. Where phosphorus resulted in sizeable yield increases, high soil moisture increased the response to phosphorus and vice versa. The effect of nitrogen fertilization was not significant.

70-71:02G-055

INFLUENCE OF SOIL SALINITY ON PRODUCTION OF DRY MATTER AND UPTAKE AND DISTRIBUTION OF NUTRIENTS IN BARLEY AND CORN: I. BARLEY (HORDEUM VULGARE L.),
Hassan, N. A. K., Drew, J. V., Knudsen, D. and Olson, R. A.
Agricultural Experiment Station, Abu-Ghraib, Iraq, Soils Department.
Agronomy Journal, Vol. 62, No. 1, p 43-45, 1970. 2 tab, 1 fig, 10 ref.
(See 70-71:05C-007)

70-71:02G-056

GROWTH AND WATER POTENTIAL OF ROOT CROPS AS INFLUENCED BY SALINITY AND RELATIVE HUMIDITY,
Hoffman, G. J., and Rawlins, S. L.
Agricultural Research Service, Riverside, California, U.S. Department of Agriculture.
Agronomy Journal, Vol. 63, No. 6, p 877-880, 1971. 4 tab, 4 fig, 12 ref.

Descriptors: *Salinity, *Relative humidity, Environment, Growth.
Identifiers: *Root crop, Leaf water potential, Osmotic potential.

The interaction of relative humidity and salinity on garden beet, onion, and radish was studied in sunlit climate chambers at temperatures cycling daily between 26 and 10 C. Average daytime relative humidity (RH) was controlled at 45 and 90%. The root medium of each crop was maintained at four different osmotic potentials, the range depending on the crop's salt tolerance. With a nonsaline root medium, increasing RH from 45 to 90% increased the yield of beet by 50% and radish by 15%, but did not enhance the yield of onion. In saline root media, high RH significantly raised the salinity level at which the yield was reduced to 50% of the nonsaline yield for onion and radish, but did not affect this level for beet. Linear relationships between leaf water (ψ_L) and osmotic (π_L) potentials and the osmotic potential of the root medium (π_s) were found for all three crops. Except at low values of π_s (high salinity), ψ_L and π_L were lower at 45% RH than at 90% RH. Leaf turgor potential was not affected by salinity in beet and onion but was reduced in radish. The relationship between crop yield and ψ_L was linear. The difference in ψ_L for plants between full yield and almost no yield was only 13 bars for beet, 6 bars for radish, and 4 bars for onion.

70-71:02G-057
ONE-DIMENSIONAL INFILTRATION INTO LAYERED SOILS,
Fok, Yu-Si.
Texas Water Rights Commission, Austin, Texas, Technical Services Division, Basin Hydrology Section.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR2, Proc. Paper 7343, p 121-129, 1970. 2 tab, 1 fig, 2 append, 4 ref.

Descriptors: *Hydrology, *Infiltration, *Permeability, *Soil physics, *Water flow, Irrigation, Water, Porosity.
Identifiers: One-dimensional infiltration.

An equation in algebraic form has been developed to describe one-dimensional infiltration into layered soils. The effect of soil properties upon the infiltration process is readily observable in this equation. This equation can be reduced to an equation describing infiltration into homogeneous soil by considering the soil profile as being one layer. The validity of this developed equation has been shown by the study of two cases of two-layered soils. Good agreement between published and computed infiltration data is obtained.

70-71:02G-058
SUBSURFACE IRRIGATION SYSTEM ANALYSIS AND DESIGN,
Fok, Yu-Si, and Willardson, L. S.
Hawaii University, Honolulu, Department of Civil Engineering.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, p 449-454, 1971. 1 fig, 2 append, 5 ref.

Descriptors: *Subsurface irrigation, *Irrigation system, *Soil water movement, Irrigation design, Infiltration, Water flow, Permeability.
Identifiers: Two-dimensional flow.

By considering the phenomenon of subsurface irrigation as a case of two-dimensional infiltration, a method is developed for analyzing the water distribution pattern in the soil profile from a subirrigation pipe placed on a barrier. Equations of soil-water movement were used to establish the design criteria of the discharge, the burial depth and the spacing of the subsurface irrigation system. A numerical example is given to show the procedures of the proposed method for subsurface irrigation system analysis and design.

70-71:02G-059
NEED FOR ENVELOPE MATERIAL ABOVE DRAINTILE,
Saulmon, R. W.
United States Department of Agriculture, Sidney, Montana.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR4, p 661-663, 1971. 1 fig, 1 append, 3 ref.
(See 70-71:02F-032)

70-71:02G-060
IRRIGATION INVESTIGATIONS IN OTAGO, NEW ZEALAND: VII. GROUND WATER AND SOIL SALINITY IN THE KUROW-DUNTROON DISTRICT,

Cossens, G. G., and Rickard, D. S.
Invermay Agricultural Research Centre, Mosgiel, Field Research Section, Dept of Agriculture, Private Bag.
New Zealand Journal of Agricultural Research, Vol. 13, No. 2, p 218-224, 1970.
2 tab, 4 ref.
(See 70-71:02F-033)

70-71:02G-061

THE MEASUREMENT AND MECHANISM OF ION DIFFUSION IN SOILS VI. THE EFFECT OF CONCENTRATION AND MOISTURE CONTENT ON THE COUNTER-DIFFUSION OF SOIL PHOSPHATE AGAINST CHLORIDE ION,

Farr, E., Vaidyanathan, L. V., and Nye, P. H.
Oxford University, Aberdeen, School of Agriculture, Department of Chemistry and Biochemistry, Soil Science Laboratory.
The Journal of Soil Science, Vol. 21, No. 1, p 15-27, 1970. 4 tab, 3 fig, 14 ref.

Descriptors: Phosphate, Diffusion, Soil, Ion uptake.
Identifiers: Resin paper, Desorption, Flux.

The observed flux of phosphate to the resin paper can be accounted for, not by the phosphate-adsorption properties of the soils, but by the phosphate diffusion in the resin-paper and the desorption relationship of the soil corresponding to the depletion of the labile phosphate in a constant indifferent-anion environment. In uptake by plant roots, if and when alternations of this desorption relationship by the roots' presence are unimportant, the supply of phosphate by diffusion in the soil would be determined by the desorption property of the labile phosphate in the presence of an indifferent anion. The resin-paper method does not provide an accurate enough measure of the diffusion coefficient to be of any practical use. For the present it seems best to calculate the diffusion coefficients using the desorption relationship, which is different for each phosphate level in the same soil, with known values of the impedance factor, until more efficient direct methods are evolved.

70-71:02G-062

TRANSIENT INFILTRATION INTO CRUST-TOPPED PROFILES,

Hillel, D., and Gardner, W. R.
Hebrew University of Jerusalem, Israel.
Soil Sciences, Vol. 109, No. 2, p 69-76, February 1970. 4 fig, 8 ref.

Descriptors: *Infiltration rates, *Soil water movement, Soil physical properties, Soil management, Soil surfaces.
Identifiers: *Crust-topped profiles, Soil water relations.

A theory is presented which describes transient infiltration into both uniform and crust-capped profiles of initially dry soil. Application of the Green and Ampt assumptions are discussed. Experimental data are shown which indicate that the cumulative infiltration curves of crusted profiles scale as the square root to their transmission-zone diffusivities. Thus, infiltration into a crusted profile can be described by the approximation that water enters into the subcrust soil at a nearly constant suction, the magnitude of which is determined by the crust resistance and the hydraulic characteristics of the soil.

70-71:02G-063

A COMPUTER ANALYSIS ON THE LEACHING OF BORON FROM STRATIFIED SOIL COLUMNS,

Tanji, K. K.
California University, Davis.
Soil Science, Vol. 110, No. 1, p 44-51, July 1970. 3 fig, 3 tab, 15 ref.

Descriptors: *Leaching, *Computer models, *Boron, Ion transport, Drainage, Percolation, Salt balance, Soil management.
Identifiers: *Stratified soil column.

A computer method was developed to predict desorption and movement of boron from laboratory columns. The Fortran program considers the Langmuir adsorption isotherm for the sorption-desorption process and a chromatographic equation for the displacement of soluble boron. Substantial computer predictions were obtained on the leaching of native soil boron from three 68.6 cm. columns stratified with respect to soluble and adsorbed boron, Langmuir constants, and water content. These predictions included boron content in the effluent and changes in profile distribution with varied amounts of leaching.

70-71:02G-064
THE EFFECT OF THE ENTRAPPED AIR ON THE HYSTERESIS CURVES OF A POROUS BODY AND ON ITS HYDRAULIC CONDUCTIVITY,
Poulovassilis, A.
Agricultural Research Council, Cambridge, England, Soil Physics.
Soil Science, Vol. 109, No. 3, p 154-162, March 1970. 8 fig, 3 ref.

Descriptors: *Hysteresis, *Groundwater movement, *Porous media, Hydraulic conductivity, Soil moisture, Timelag, Viscosity.
Identifiers: *Entrapped air.

Due to the entrapped air, a family of drying curves occurs between the saturation and the ultimate boundary drying curves for a porous body. This makes it possible to obtain a family of primary wetting curves for which the starting point for each is defined by the same suction but lies on one of various drying curves, as well as to measure the hydraulic conductivity along numerous drying curves. Results are reported and explained.

70-71:02G-065
EFFECTS OF SOIL TEXTURE ON EVAPORATIVE LOSS AND AVAILABLE WATER IN SEMI-ARID CLIMATES,
Alizai, H. U., and Hulbert, L. C.
Kansas State University, Manhattan.
Soil Science, Vol. 110, No. 5, p 328-332, November 1970. 2 fig, 4 tab, 14 ref.
(See 70-71:02D-021)

70-71:02G-066
AIR PERMEABILITY AS RELATED TO PARTICLE SIZE AND BULK DENSITY IN SAND SYSTEM,
Elgabaly, M. M., and Elghamry, W. M.
Alexandria University, United Arab Republic.
Soil Science, Vol. 110, No. 1, p 10-13, July 1970. 1 fig, 2 tab, 16 ref.
(See 70-71:07B-006)

70-71:02G-067
MEASUREMENT OF UNSATURATED CONDUCTIVITY AND DIFFUSIVITY BY INFILTRATION THROUGH AN IMPEDING LAYER,
Hillel, D., and Gardner, W. R.
Wisconsin University, Madison.
Soil Science, Vol. 109, No. 3, p 149-153, March 1970. 2 fig, 10 ref.
(See 70-71:07B-007)

70-71:02G-068
INFILTRATION INDUCED SOIL INSTABILITIES,
Adrian, D. D.
Massachusetts University, Amherst, Civil Engineering Department.
Groundwater Hydrology, Vol. 8, No. 1, p 29-36, January-February 1970. 6 fig, 7 ref.

Descriptors: *Infiltration rates, *Permeability, Pore pressure, Soil water, Irrigation.
Identifiers: *Impermeable barrier, Wetting front, Capillary force.

This article confirms that strong capillary forces can hinder instead of help promote infiltration into soils. Infiltration into an unsaturated soil overlying an impermeable barrier displaces the air from the soil. Unable to escape downward, the air may escape upward in bubbles traveling through large pores, or if the pores are small the air is compressed between the wetting front and the barrier. This reduces the infiltration rate and may result in an almost stable wetting front. Observations have shown that when the air was allowed to escape the wetting front moved 3 inches in less than one minutes; when the air was not allowed to escape, it took 2 weeks for the front to move the same distance. This phenomenon should emphasize precautions to be followed in applying laboratory results to field conditions.

70-71:02G-069
MODEL THEORY FOR PREDICTING PROCESS OF LEACHING,
Alfaro, J. F., Keller, J.
Utah State University, Logan, Utah.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3,
p 263-268, March 1970. 7 fig, 8 ref.

Descriptors: *Soil science, *Soil chemistry, *Leaching, Model studies, Salinity, Irrigation practices.
Identifiers: *Pollution sources, Salt loading, Salinization.

A theory for using physical scaled models to predict the leaching process is developed and tested. This theory is based on the fact that when the function that governs a process is the same for two or more physical systems, observations made on one system predict the performance of the other. The theory was tested on uniform and layered soil profiles constructed of artifically salinized samples of Bear River sand and nibley silty clay loam soil, while the layered profiles consisted of the nibley soil only. Findings suggest that the effluent concentration curve can be predicted from the results obtained by leaching a scaled model.

70-71:02G-070
RELATION OF MOISTURE CONTENT TO FAILURE STRENGTHS OF SEVEN AGRICULTURAL SOILS,
Chancellor, W. J., and Vomocil, J. A.
California University, Davis.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 1,
p 9-17, January 1970. 9 fig, 2 tab, 8 ref.
(See 70-71:08D-005)

70-71:02G-071
FACTORS AFFECTING THE DETERMINATION OF AVAILABLE SOIL NITROGEN BY CHEMICAL METHODS: I. COMPARISON OF EXTRACTABLE WITH MINERALIZED NITROGEN.
Verstraeten, L. M. J., Vlassak, K., and Livens, J.
Louvain University, Belgium.
Soil Science, Vol. 110, No. 5, p 299-305, November 1970. 4 fig, 2 tab, 12 ref.

Descriptors: *Soil chemistry, *Nitrogen compounds, Inorganic compounds, Soil gases.
Identifiers: *Soil extract, *Soil fertility.

Several water soluble nitrogen fractions are correlated with the mineralized nitrogen after 32 days of incubation at 30°C. Highest correlation was found for cold water extracts. Analysis of the results prove that cultivated and forest soils must be separated prior to calculating regression lines. Sandy soils do not behave the same as loamy or clayey soils. It can be concluded that both vegetation and soil texture exert their influence on the nitrogen index.

70-71:02G-072
ALLOCATION OF CATION EXCHANGE CAPACITY TO SOIL FRACTIONS IN SEVEN SURFACE SOILS FROM PANAMA,
Martini, J. A.
Institute Interamericano de Ciencias Agricolas de la OEA, Turrialba, Costa Rica.
Soil Science, Vol. 109, No. 5, p 324-331, May 1970. 1 fig, 6 tab, 19 ref.

Descriptors: *Soil chemistry, *Soil classification, Soil engineering, Soil groups, Soil investigations, Soil management, Cation exchange capacity, Soil science, Soils.

The cation exchange capacity and mineralogy of tropical soils is most variable due to the diversity in ecosystems and great soil groups encountered. In some soils the CEC could not be fully accounted for by either allophane, clay minerals or organic matter. It is believed that this is due to higher CEC values obtained at pH 7.0 rather than at the native soil pH (16) and to other analytical errors such as retention of acetate when using the ammonium acetate method. It was of particular interest to note that relatively high contribution of the silt fraction to the soil cation exchange properties, particularly in the alluvial and lateritic soils. A weathering index (Iw) or cation exchange factor (CEF) was obtained by dividing the clay activity (meq./100 g. clay) by the percent clay (per cent of active material). This index was applied to the soil data to place the soils in a certain weathering sequence.

70-71:02G-073
MOLYBDENUM REQUIREMENT OF CROPS GROWN ON A SANDY CLAY LOAM SOIL IN THE GREENHOUSE,
Gupta, U. C.
Canada Department of Agriculture, Charlottetown, P.E.I., Research Station, Research Branch.
Soil Science, Vol. 110, No. 4, p 280-282, October 1970. 2 tab, 8 ref.

Descriptors: *Soil chemistry, *Molybdenum, *Podzols, Alfalfa, Clovers.
Identifiers: *Micronutrients, Brussel sprouts, Red clover, Spinach, Timothy.

The results suggest that the optimum tissue levels of molybdenum in various crops were: alfalfa, 0.12 to 0.46; red clover, 0.46 to 1.08; timothy, 0.41 to 0.71; brussel sprouts, 0.11 to 0.22; and spinach, 0.15 to 0.24 ppm. Since there has been little work done on the molybdenum content of crops grown on podzol soils, these results should be of great value in choosing soil molybdenum levels to determine tissue levels of molybdenum for optimum growth of crops under field conditions.

70-71:02G-074
COMPUTER SIMULATION OF TILE SYSTEMS,
Bird, N. A., and McCorquodale, J. A.
Ontario Department of Agriculture and Food, Stratford, Canada, and Windsor University, Windsor, Canada, Dept of Civil Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 1, p 175-178, January 1971. 7 fig, 8 ref.

Descriptors: *Soil physics, *Irrigation engineering, *Tile drainage, Soil moisture, Sprinkler irrigation, Computer models, Mathematical models, Drainage.

The object of this study was to develop a mathematical water balance model that would predict the performance of a tile system by predicting the tile runoff hydrographs. The model included an existing available soil moisture model and an empirical model. The accurate performance of the model was limited by the accuracy of the soil moisture model. An improved available moisture model would permit the prediction of water table heights and tile runoff rates. The feasibility of sprinkler irrigation could also be studied, using the model.

70-71:02G-075
CONTROL OF SOIL MOISTURE DURING SPRINKLER IRRIGATION,
Keller, J.
Utah State University, Logan, Agricultural and Irrigation Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 6,
p 885-890, June 1970. 6 fig, 2 tab, 18 ref.

Descriptors: *Soil physics, *Irrigation practices, *Irrigation engineering, Sprinkler irrigation, Infiltration rates, Drainage.
Identifiers: *Soil-water relationships, Application rate.

A laboratory experiment was carried out on 6-in. by 20-in. long columns of four different soils and a sand. The soils tested were a loamy sand, a silty clay loam, and two similar silt loams. Water was uniformly applied to the soil columns which were supplied with controlled drainage and the tests were conducted on several columns of each soil packed at various initial bulk densities. From the information presented the basic infiltration rate and the degree of saturation associated with various application rates can be estimated for the soil at any bulk density.

70-71:02G-076
CROP RESIDUE DISPOSAL-TILAGE-PLANTING RELATIONSHIPS,
Colwick, R. F., Jones, J. W., and Fulgham, F. E.
United States Department of Agriculture, Agricultural Research Service, State College, Mississippi.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 1,
p 114-120, January 1971. 15 fig, 7 tab, 6 ref.

Descriptors: *Crop production, *Planting management.
Identifiers: Crop residue, Tillage.

Cotton plant residue is a waste product that must be managed so that it causes a minimum amount of interference with the cultural operations for the succeeding crop. This study was designed to determine the relationship of residue size, plant part, soil type and depth of soil incorporation to the strength of decomposed residue at planting and to determine the influence of residue size on planter performance. Decomposition was measured by the decrease in peak force and energy required to break sample pieces that had been weathering at several depths through the winter months. Residue left on the soil surface decayed the least, and was significantly stronger than residue placed at other depths. There was a tendency for better decomposition at the 4-in. depth of burial than at 2-in. and 6-in., but there were no differences in decayed strength due to length of pieces or soil type.

70-71:02G-077
A STUDY OF TWO-DIMENSIONAL INFILTRATION,
Fok, Yu-Si.
Hawaii University, Honolulu, Dept of Civil Engineering and Water Resource, Research Center.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 15,
p 676-681, May 1970. 2 fig, 2 ref.
(See 70-71:02F-051)

70-71:02G-078
A MODEL STUDY OF DRAIN ENVELOPES IN A COARSE-SILT BASE MATERIAL,
Lembke, W. D., and Bucks, D. A.
Illinois University, Urbana, Agricultural Engineering Department; and Soil and Water Conservation Laboratory, Phoenix, Arizona.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 15,
p 669-675, May 1970. 7 fig, 2 tab, 8 ref.
(See 70-71:02F-052)

70-71:02G-079
UNLINED MOLE LINES FOR IRRIGATION,
Norum, D. I., and Gray, D. M.
Saskatchewan University, Saskatoon, Canada.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5, p 661-668, May 1970. 3 fig, 1 tab, 11 ref.

Descriptors: *Irrigation practices, *Subsurface irrigation, *Irrigation systems, Water spreading, Irrigation.
Identifiers: Mole lines.

A study was conducted in several alluvial soils in the Canadian Prairies to investigate the feasibility of the use of unlined mole lines for irrigation. The findings provide useful practical information which can be applied in construction and design. Findings were as follows: Mole lines used for irrigation should be placed on the contour; Moisture movement outward from mole lines occurs as a wet front; and the rate of advance and the shape of the wet front is affected greatly by soil anistropy.

70-71:02G-080
VISIBLE AND NEAR INFRARED RLMOTE-SENSING OF SOIL MOISTURE LEVELS,
Sewell, J. I., Allen, W. H., and Pile, R. S.
Tennessee University, Knoxville.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 6, p 1163-1166, June 1971. 5 fig, 4 tab, 9 ref.

Descriptors: *Soil moisture, *Remote sensing, Infrared radiation, Instrumentation, Measurements, Mapping.

Infrared sensing techniques similar to those employed in plant species determination and in detecting plant diseases were used. These included laboratory and field experiments designed to evaluate field soil-moisture levels through analysis of optical densities of images produced from color and black-and-white infrared films and infrared scanner outputs on film. The results show conclusively that detecting differences between surface soil moisture levels of fallow soils is technically possible. Best results were obtained using color infrared film and Wratten No. 15 or No. 15 plus 80B film filters. Situations to be avoided are: varying cloud cover, different sun angles, different film lots, and different processing runs. Evaluating soil moisture levels of soils having heavy vegetal cover will probably be different.

70-71:02G-081
A DIGITAL SIMULATION OF THE DYNAMIC SOIL MOISTURE STATUS,
Jones, J. W., and Verma, B. P.
Mississippi State University, State College, United States Department of Agriculture, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4, p 660-664, April 1971. 6 fig, 8 ref.

Descriptors: *Model studies, *Soil moisture, *Computer models, Soil physics, Mathematical models, Diffusion, Moisture availability.

A soil moisture model was designed and tested for simulating soil moisture values for soils exposed to natural weather. For 43 days the predicted values were usually within ten percent of the actual data. The model is considered adequate for use in some studies involving a crop production model where environmental inputs are necessary. The model is sensitive to the choice of saturated soil moisture and insensitive to the choice of air dry value. The relationship between diffusivity and soil moisture is a primary factor in determining the accuracy of the model.

70-71:02G-082
STRESS DAY INDEX TO CHARACTERIZE EFFECTS OF WATER STRESS ON CROP YIELDS,
Hiler, E. A., and Clark, R. N.
Texas A & M University, College Station, Texas.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4,
p 757-761, April 1971. 2 fig, 2 tab, 28 ref.

Descriptors: *Soil-water-plant relationships, *Soil moisture, *Plant growth, Soil water, Soil physics, Irrigation engineering.
Identifiers: *Crop yields, *Stress day index, Irrigation scheduling.

This paper concerns quantitative characterization of water stress in crops with stress day index (SDI) and its effect on crop yields. The SDI is determined from a stress day (SD) factor and a crop susceptibility factor (CS). The SD factor is a measure of the degree and duration of plant water deficit. The CS factor indicates the plant's susceptibility to water deficit at various growth stages. Alternative approaches to determination of SD and CS are given. Relationships between SDI and yield are determined from results of grain sorghum and peanut irrigation experiments. Various applications of the SDI concept are discussed briefly.

70-71:02G-083
NITROGEN FIXATION BY NONSYMBIOTIC MICROORGANISMS IN SOME CALIFORNIA SOILS,
Steyn, P. L., Delwiche, C. C.
California University, Davis.
Environmental Science and Technology, Vol. 4, No. 12, p 1122-1128, December
1970. 2 fig, 5 tab, 32 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, *Nitrogen compounds, Nitrification, Water pollution sources, Nitrogen fixation, Nitrogen cycle, Nitrogen fixing bacteria, Microorganisms, Microbiology.

The rate of nitrogen fixation by soil samples from various California environments was determined at monthly intervals for a period of one year by comparing direct isotopic observations of fixation rates with rates determined by the acetylene-ethylene method. Annual fixation rates of approximately 5 kilograms nitrogen per hectare per year were observed in the most favorable environment examined, and rates as low as 2 kilograms per year were observed on a more arid site with native vegetation. Observations made by direct isotopic methods compared reasonably well with those obtained with use of the acetylene-ethylene method, but some variability between the two occurred. Limiting factors in the fixation reaction are reported and the significance of observed rates is discussed.

70-71:02G-084
A MODIFIED INFLOW-OUTFLOW METHOD OF MEASURING INFILTRATION IN FURROW IRRIGATION,
Nance, L. A., Jr., and Lambert, J. R.
United States Department of Agriculture, Columbia, South Carolina, Soil Conservation Service.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 6,
p 792-798, June 1970. 9 fig, 7 ref.

Descriptors: *Irrigation practices, *Infiltration, *Percolation, Permeability, Hydraulic conductivity, Furrow irrigation.
Identifiers: Intake rates.

A modified inflow-outflow method for calculating infiltration is described. Five tests of the method were made. Three were made simultaneously with the modified Bondurant method. All of the tests were made within a 0.3-acre plot of ground with most of the test sites adjoining one another. The method was found feasible for measuring infiltration rates for furrow irrigation. It approximated the furrow irrigation process, was easy to control in the field, required preparation of only three 15-foot furrows and yielded satisfactory data. The system was capable of operating over a large range of flow rates.

70-71:02G-085
SALINITY AND WATER USE,
Talsma, T., and Philip, J. R.
The MacMillan Press, London, England. 1971. 296 p, 2 append.
(See 70-71:01B-002)

70-71:02G-086
CHEMISTRY OF SALINE SOILS AND THEIR PHYSICAL PROPERTIES,
Quirk, J. P.
University of Western Australia, Institute of Agriculture, Dept of Soil Science and Plant Nutrition.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 79-91. 2 fig, 1 tab, 32 ref.

Descriptors: *Soil chemistry, *Saline soils, *Soil water, *Dispersion, Soil density, Salinity, Soil structure, Soil physics, Soil management, Soil dispersants.

An outline of the forces involved in clay particle interaction (swelling and dispersion) is given as a background for the interpretation of the physical behavior of sodic soils, especially in relation to electrolyte levels. The electrolyte concentration below which appreciable decreases in soil permeability are encountered has been termed the threshold concentration and this concentration increases with the degree of sodium saturation of the soil colloids. The application of the threshold concentration concept to the management and reclamation of sodic soil is discussed.

70-71:02G-087
HYDROLOGY OF SWELLING SOILS,
Philip, J. R.
Division of Environmental Mechanics, Canberra, Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 95-107. 7 fig, 23 ref.

Descriptors: *Hydrology, *Soil chemistry, *Soil water, *Soil density, Dispersion, Salinity, Soil structure, Soil physics, Soil management, Soil dispersants.
Identifiers: Soil swelling.

Not all saline soils swell, and not all swelling soils are subject to salinity problems; but hydrologic difficulties often arise in connexion with the drainage and reclamation of swelling clays in flat landscapes. The paper reviews recent progress in the theory of water equilibrium and movement in swelling soils, and emphasizes that neglect of the fact of swelling may lead to serious errors of interpretation. The point of departure is the well-established theory of water equilibrium and movement in nonswelling soils. The generalization to swelling soils is described. It is stressed that, in swelling soils, the total potential includes an additional component, the overburden potential. Classical concepts of groundwater hydrology, tacitly based on the behaviour of nonswelling soils, fail in many important ways for swelling ones. Aspects which differ profoundly from those of nonswelling soils include the following: equilibrium moisture profiles, the distribution of hydraulic conductivity relative to the water table, the effect of topography on moisture distribution, the variation of specific yield with water table elevation and stratum thickness, and the character of steady and unsteady vertical flows.

70-71:02G-088
OVERLAND FLOW HYDROGRAPH ANALYSIS TO DETERMINE INFILTRATION FUNCTION,
Wu, I. P.
Hawaii University, Honolulu, Agricultural Engineering Department.

American Society of Agricultural Engineers, Transactions, Vol. 14, No. 2, p 294-300, February 1971. 11 fig, 11 ref.

Descriptors: *Irrigation practices, *Infiltration, *Mathematical models, Percolation, Permeability, Hydraulic conductivity.
Identifiers: Overland flow.

A method is presented to determine the infiltration function. The flow pattern of surface irrigation is nonuniform, unsteady, and spatially varied. Resulting from a combination of the effects of surface flow, surface roughness, and infiltration. This flow is expressed as one set of partial differential equations of the hyperbolic type: a continuity equation and an equation of motion. The method proposed uses the concept of overland-flow hydrograph. The analysis of the hydrograph provided an approximation of the infiltration expressed as a function of distance of run and time. The hydrographs also clearly showed conditions of surface flow for which mathematical equations of infiltration were derived.

70-71:02G-089
NUMERICAL SOLUTIONS FOR THE RADICAL SUBSURFACE FLOW PROBLEM
Drake, Ronald L., and Ellingson, Michael B.
National Center for Atmospheric Research, Boulder, Colorado, Atmospheric Science Laboratory.
Groundwater, Vol. 8, No. 6, p 39-47, November-December 1970. 9 p, 6 fig, 2 tab, 7 ref.

Descriptors: *Soil water movement, *Numerical analysis, *Unsteady flow, *Unsaturated flow, *Diffusivity, Mathematical studies, Percolation, Subsurface flow.
Identifiers: *Racial subsurface flow.

Two stable finite difference schemes are presented for the numerical solution of the nonlinear partial differential equation describing the radial flow of soil moisture. The nonlinearily exists because soil moisture diffusivity is a nonconstant function of the nondimensional soil moisture. Numerical solutions are given for 21 different moisture-dependent diffusivities. From these numerical solutions quantitative results are obtained for the following: (1) the boundedness and monotonicity of the moisture distribution; (2) the continuous dependence of the moisture distribution on the system's parameter, namely, the diffusivity; (3) the rate at which the wetting front approaches the steady state solution, (4) the evolution of the moisture front with time and with the formulation of the diffusivity; and (5) the time evolution of the rate of inflow or outflow at the wall of the source or sink.

70-71:02G-090
PREDICTING IRRIGATIONS FROM CLIMATIC DATA AND SOIL PARAMETERS,
Franzoy, C. E., Tankersley, E. L.
Salt River Project, Phoenix, Arizona.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 6, p 814-816, June 1970. 4 fig, 4 ref.

Descriptors: *Irrigation practices, *Irrigation efficiency, Irrigation engineering, Irrigation programs, Crop growth, Computer models.
Identifiers: *Irrigation scheduling, Irrigation timing, Irrigation amounts.

The Jensen program for irrigation scheduling was rewritten for the computer at the Salt River Project and was tested on 2162 acres located on 19 farms in the Salt River Valley. Procedure and results of that application are reported. The conclusions drawn from this study are: (1) The use of climatic data and soil parameters for scheduling irrigations provides control of the soil moisture reservoir essential for optimum yields. (2) Scheduling irrigations is an excellent supplement too, but not a replacement for regular field visits, and (3) On the basis of the results to date, the Jensen predictive method offers a sound basis for predicting irrigation timing based on climatic data. The study will be continued with some modifications.

SECTION VIII

WATER CYCLE

LAKES (Group 02H)

70-71:02H-001
PALYNOLOGICAL TRACING OF SALINE WATER SOURCES IN LAKE KINNERET REGION(ISRAEL),
Horowitz, A.
Hebrew University, Jerusalem (Israel), Dept of Geology.
Journal of Hydrology, Vol. 10, No. 2, p 177-184, February 1970. 8 p, 1 fig, 2 tab, 17 ref.

Descriptors: *Saline water systems, *Springs, *Lakes, *Tracking techniques, *Palynology, Brines, Discharge (Water), Groundwater movement, Tracers, Water chemistry, Water quality, Mixing, Water sources, Provenance.
Identifiers: Lake Kinneret (Israel).

Palynological spectra of water samples representing four groups of saline sources are compared with a freshwater spectrum in Lake Kinneret region. The palynological spectra indicate that the saline waters are a mixture of recent water with active aquifers from an intake area in the mountains west of the lake that dilute in various proportions concentrated saline solutions of Upper Pliocene to Lower Pleistocene age.

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SECTION IX

WATER CYCLE

WATER IN PLANTS (Group 02I)

70-71:02I-001
CORN YIELDS, SOIL TEMPERATURE, AND WATER USE WITH FOUR TILLAGE METHODS IN THE WESTERN CORN BELT,
Olson, Tamlin C., and Schoeberl, La Vern S.
Agricultural Research Service, Brookings, South Dakota, Corn Belt Branch; and South Dakota Agricultural Experiment Station, Brookings.
Agronomy Journal, Vol. 62, No. 2, p 229-232, March-April 1970. 1 fig, 5 tab, 11 ref.

Descriptors: *Crop production, *Corn, *Water utilization, *Corn belt, *Cultivation, Semiarid climates, South Dakota, Soil temperature, Plant growth, Rainfall, Erosion, Soil erosion, Runoff, Water loss, Water conservation, Soil water, Soil moisture, Planting management.
Identifiers: *Plowing, *Listing, *Till planting, *Wheeltrack planting.

Corn yield and growth characteristics were compared for 4 tillage systems during crop years 1965, 1966, 1967, and 1968. The 4 methods under study were conventional plowing, wheeltrack planting, till planting, and listing. Although the difference was not significant between the four systems, the three reduced-tillage methods tended to have higher average grain yields. Rainfall during the four test years was below normal, so that the runoff-conserving characteristics of the reduced-tillage systems had little influence on the amount of water available to growing corn. Nonetheless, the experimental results show that the reduced-tillage methods can be used in the Corn Belt without sacrificing grain yield. These systems are also more economical and better able to protect against soil erosion and runoff.

70-71:02I-002
EXTRACTION TERM MODELS OF SOIL MOISTURE USE BY TRANSPIRING PLANTS,
Molz, F. J., and Remson, Irwin.
Stanford University, California.
Water Resources Research, Vol. 6, No. 5, p 1346-1356, October 1970. 11 p, 6 fig, 1 tab, 18 ref.

Descriptors: *Soil-water-plant relationships, *Transpiration, *Soil water movement, *Moisture uptake, *Root systems, Velocity, Unsaturated flow, Mathematical models, Respiration, Translocation, Soil moisture, Flow, Hydraulic conductivity, Moisture content, Moisture availability, Water utilization, Root zone.
Identifiers: Soil water extraction.

A mathematical model is developed describing moisture removal from soil by the roots of transpiring plants. The model uses a macroscopic extraction term in the one-dimensional soil moisture flow equation. It describes both moisture removal by the plant and induced moisture movement through the soil. A numerical procedure based on the Douglas-Jones predictor-corrector method is used to solve the model, and solutions are compared with experimental data. The results indicate that extraction term models are computationally and physically feasible and give insight into the mechanics of the overall moisture extraction process.

70-71:02I-003
EFFECT OF MULCHES AND BED CONFIGURATION. II. SOIL TEMPERATURE AND GROWTH AND YIELD RESPONSES OF GRAIN SORGHUM AND CORN,
Adams, J. E.
Agricultural Research Service, Temple, Texas.
Agronomy Journal, Vol. 62, No. 6, p 785-790, 1970. 1 tab, 7 fig, 17 ref.

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Descriptors: *Mulch, *Soil temperature, *Plant growth, Grain sorghum, Corn, Yield, Evaporation control.
Identifiers: *Plastic mulch, *Petroleum mulch, Seedbed configuration, Morphological development, Grain sorghum (Sorghum bicolor (L.) Moench), Corn (Zea mays (L.)).

Clear plastic film and petroleum mulch were used on Austin clay and Houston Black clay to evaluate their effects on soil temperature and on the growth, development, and yield responses of corn (Zea mays L.) and grain sorghum (Sorghum bicolor (L.) Moench). Three bed configurations also were used in conjunction with the mulches with grain sorghum. Mulches had a highly significant effect on average soil temperature at 7.6 cm below the surface. Soil temperature under clear plastic film 3 weeks after planting had increased 2.6, 2.2, and 1.8C at depths of 30, 61, and 91 cm, respectively. Mulches increased the rate of growth of both corn and grain sorghum significantly (5 percent level) and also affected morphological development, with clear plastic having the most effect. Bed configuration had a significant effect on sorghum growth when used with mulches. Clear plastic mulch accelerated growth and morphological development sufficiently to cause 50 percent bloom to occur 8 to 10 days earlier for both corn and grain sorghum. Clear plastic mulch increased grain sorghum yield significantly, but mulches had no significant effect on corn yield. Bed configuration caused a significant increase in grain sorghum yield in 1964 but had no important effect on yield in 1963.

70-71:02I-004
WATER DEFICIT EFFECTS ON CORN. I. VEGETATIVE COMPONENTS,
Claassen, M. M., and Shaw, R. H.
Iowa State University, Ames, Agronomy Department.
Agronomy Journal, Vol. 62, No. 5, p 649-652, 1970. 2 tab, 2 fig, 10 ref.

Descriptors: *Moisture stress, *Moisture deficit, *Wilting, *Yields, Corn, Fertility, Soil moisture.
Identifiers: Corn growth stages, Corn (Zea mays L.).

Corn was grown in large buried containers and stressed nonrepetitively by cessation of irrigation at nine different times during the season. Each stress treatment consisted of 4 days on which the uppermost, fully-expanded leaves were wilted. Water status of the yield plants was estimated in terms of the relative turgidity (RT) of like-treated plants, soil moisture and other environmental factors. Vegetative component yields were determined in two experiments, the first including the additional factor of limiting soil fertility. Each component was significantly influenced by one or more of the stress periods. Maximum reductions in total vegetative dry matter production of 15 to 17 percent resulted from water deficits approximately 3 weeks before 75 percent silking. Significant increases in stalk weight occurred as a result of stress at late silking and very early ear stages.

70-71:02I-005
WATER DEFICIT EFFECTS ON CORN. II. GRAIN COMPONENTS,
Claassen, M. M. and Shaw, R. H.
Iowa State University, Ames, Agronomy Department.
Agronomy Journal, Vol. 62, No. 5, p 652-655, 1970. 1 tab, 8 fig, 6 ref.

Descriptors: *Moisture stress, *Moisture deficit, *Yields, Corn, Fertility, Soil moisture.
Identifiers: Corn growth stages, Kernel weight corn (Zea mays L.).

Under controlled irrigation, corn plants grown in large containers were subjected to water deficits in one of nine periods during each of two growing seasons. The first experiment (1965) differed from the second (1966) by somewhat different timing of treatments and by limiting soil fertility conditions. A significant grain yield reduction (12 to 15 percent) was observed after stress during the vegetative period at early ear shoot and ovule development in 1966. A 53 percent grain yield reduction was associated with stress at 75 percent silking in 1965. In the 3-week period after silking, water deficits consistently reduced yields approximately 30 percent in both years. Significant reductions in kernel numbers were associated with yield reductions from stress before or during silking and pollination. Kernel weights were significantly reduced by stress during or after silking. Trends in the percentage of developed kernels in each of three ear sections indicated that the ability of kernels to compete for products of photosynthesis correlated with the comparative age of the ovule or kernel at the time of water deficit.

70-71:02I-006
LIMITATION TO WATER FLUX FROM SOILS TO PLANTS,
Lang, A. R. G., and Gardner, W. R.
Division of Irrigation Research, Griffith, N.S.W., Australia, Commonwealth
Scientific and Industrial Research Organization.
Agronomy Journal, Vol. 62, No. 6, p 693-695, 1970. 1 tab, 2 fig, 8 ref.

Descriptors: *Moisture uptake, Cotton, Biological uptake, Soil moisture.
Identifiers: Water potential, Flux density.

From theoretical consideratiors it can be shown that there is an upper limit to the rate at which water car be taken up from the soil by plant roots. This occurs when the unsaturated permeability of the soil adjacent to the roots decreases more rapidly than the increase in the water potential gradient. Flux and water potential measurements obtained experimentally on cotton plants are consistent with this conclusion.

70-71:02I-007
RESPONSE OF LOWLAND RICE TO VARYING LEVELS OF SOIL, WATER, AND FERTILITY MANAGEMENT IN DIFFERENT SEASONS,
Pande, H. K., and Mittra, B. N.
Agricultural Engineering Department, I.I.T. Kharagpur, India.
Agronomy Journal, Vol. 62, No. 2, p 197-200, 1970. 3 tab, 17 ref.

Descriptors: Rice, Submergence, Chemical properties, Fertilization.
Identifiers: Soil manipulation, Atmospheric evaporative demand.

Performance of rice on lateritic soil was studied under three levels each of soil submergence, soil fertilization, and soil manipulation in the two rice growing seasons, aus and boro. In both seasons the grain yield was better under submergence than under saturation. The crop under shallow submergence (5 ± 3 cm) yielded as much as under deeper submergence (10 ± 3 cm). The crop growth under soil bulk density of 1.68 g/cc or above, obtained through puddling or compaction, performed equally well. With the increasing level of submergence, the P, Fe, and Si contents of grains increased, but, Mn content decreased in the two seasons.

70-71:02I-008
DIURNAL CHANGES IN COTTON LEAF AND PETIOLE MOISTURE CONTENT AS RELATED TO ENVIRONMENTAL MOISTURE STRESS,
Longenecker, D. E., and Lyerly, P. J.
Texas A & M University Agricultural Research Station, El Paso, Texas.
Agronomy Journal, Vol. 63, No. 6, p 885-886, 1971. 1 tab, 1 fig, 12 ref.

Descriptors: *Moisture stress, *Moisture content, Irrigation, Soil-plant-water relationship, Cotton, Diurnal distribution.
Identifiers: Plant moisture Petiole moisture, Leaf moisture content.

Continuation of gravimetric moisture content studies of topmost mature upland (Gossypium hirsutum L.) and American Pima (Gossypium barbadense L.) cotton leaves and petioles is reported. Diurnal moisture percentages of four varieties at 3 hours (7 to 8 a.m., 1 to 2 p.m. and 6 to 7 p.m.) during the day, and at 4, 11, 18, 25, and 32 days after irrigation are given. Results indicate that diurnal fluctuations in petiole moisture are less than those of leaves. Petiole moisture appears strongly related to the internal moisture stress conditions of the plant, both diurnally and with increasing environmental moisture stress. Ranges of moisture variation for leaves and petioles are shown to be similar. Previous findings that fresh weight petiole moisture percentages were continuously higher than those of attached leaves are substantiated.

70-71:02I-009
CONSUMPTIVE USE OF WATER BY ALFALFA IN WESTERN NEBRASKA,
Daigger, L. A., Axthelm, L. S., and Ashburn, C. L.
Nebraska Agricultural Experiment Station, Mitchell, Nebraska.
Agronomy Journal, Vol. 62, No. 4, p 507-508, 1970. 4 tabs, 7 ref.
(See 70-71:03F-036)

70-71:02I-010
INFLUENCE OF ROW SPACING, IRRIGATION, AND WEEDS ON DRYLAND FLAX YIELD, QUALITY, AND WATER USE,
Alessi, J., and Power, J. F.
Agricultural Research Service, Mandan, North Dakota.
Agronomy Journal, Vol. 62, No. 5, p 635-637, 2 tab, 2 fig, 14 ref.
(See 70-71:03F-037)

70-71:02I-011
DYNAMIC SIMULATION OF PLANT GROWTH AND ENVIRONMENT IN THE GREENHOUSE,
Takakura, T., Jordan, K. A., and Boyd, L. L.
Minnesota University, St. Paul.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5, p 964-971, May 1971. 8 fig, 1 tab, 20 ref, 2 append.

Descriptors: *Plant growth, *Computer models, Greenhouses, Automation.

The effects of environmental conditions on the plant leaf within a greenhouse have been simulated by hybrid techniques on the digital computer. The simulation model developed in the present study provides better analysis of the relationship between plant leaf temperature and the environment as the complexity of the model increases. Expanding this model the prediction of the plant photosynthesis in the greenhouse and computer control of greenhouses will be able to be achieved based upon plant leaf temperature which has a more significant effect on plants than air temperature.

70-71:02I-012
EFFECT OF CONSTANT SALINITY LEVELS ON WATER-USE EFFICIENCY OF BEAN AND COTTON,
Hoffman, G. J., and Phene, C. J.
United States Salinity Laboratory, Riverside, California.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 6, p 1103-1106, June 1971. 4 fig, 3 tab, 13 ref.

Descriptors: *Salinity, *Crop response, *Salt tolerance, Plant growth, Growth rates, Metabolism, Soil-water-plant relationships, Environmental effects, Growth chambers, Saline soils.

Hourly measurements of net photosynthesis, respiration and transpiration were made on bean and cotton at three salinity levels in a microchamber where ambient temperature, dewpoint temperature, carbon dioxide concentration, photoperiod, light intensity, and air velocity are controlled precisely. Water and osmotic potential measurements on detached leaves were also made. On a per unit leaf area basis, increases of salinity in bean and cotton decreased net photosynthesis and transpiration and increased respiration. Hourly respiration rates were essentially constant during the night, but hourly net photosynthesis rates decreased toward the end of the day. Hourly transpiration rates followed a diurnal cycle.

70-71:02I-013
DYNAMIC SIMULATION OF PLANT GROWTH--PART II. INCORPORATION OF ACTUAL DAILY WEATHER AND PARTITIONING OF NET PHOTOSYNTHATE,
Curry, R. B., and Chen, L. H.
Ohio Agricultural Research and Development Center, Wooster.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 6,
p 1170-1174, June 1971. 6 fig, 17 ref.

Descriptors: *Plant growth, *Computer models, *Dynamic programming, Growth rates, Mathematic models, Irrigation effects.

The dynamic simulation model of plant growth has been developed for corn to the point it will simulate reasonably close the growth and development of the corn plant. The simulator will respond to variable weather data. Moisture stress was shown to have an effect on simulated growth. The concept of competition was demonstrated. The model can be used to test various plant growth parameters both physiological and environmental to determine which ones might be key factors in increasing efficiency of production. These then could be studied in a growth chamber or in the field. The modifications suggested by simulation might be ones that needs genetic research or ones that would respond to a change in environmental management.

70-71:02I-014
MODELING SUBSYSTEMS FOR COTTON--THE COTTON PLANT SIMULATION,
Stapleton, H. N., and Meyers, R. P.
Arizona University, Tucson.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5,
p 950-953, May 1971. 11 fig, 1 tab, 4 ref.

Descriptors: *Computer models, *Plant growth, *Cotton, Mathematical models, Fiber crops.

The methodology for a simulation for the cotton plant's dynamic development as shown, should provide a basis for simple input/output models, and for models permitting complex distributive analysis of subsystems and parallel systems in the ecology. The practical applications permit the development of information which can be used as input to decision in managing the Cotton Production System.

70-71:02I-015
AIR AS A SOURCE OF LEAD IN EDIBLE CROPS,
Ter Haar, G.
Ethyl Corporation Research Laboratory, Ferndale, Michigan.
Environmental Science and Technology, Vol. 4, No. 3, p 226-230, March 1970.
1 fig, 5 tab, 13 ref.

Descriptors: *Crop production, *Pollution sources, *Pollution effects, Lead, Air pollution.
Identifiers: Airborne lead, Soil lead.

The effect of airborne lead on the lead concentration of the edible and non-edible portions of several important types of food crops was studied by growing crops in greenhouses supplied with filtered and ambient air, and in plots planted in long rows perpendicular to a busy highway. Of the ten crops studied--wheat, potatoes, tomatoes, sweet corn, carrots, cabbage, oats, rice, leaf lettuce, and snap beans--eight were not affected by the concentration of lead in air. In both sets of tests, inedible portions of the plants (bean leaves, corn husks, soybean husks, and oat, wheat, and rice chaff) showed a two- to three-fold increase in lead concentration when grown near the road or in the greenhouse with unfiltered air. The conclusions are reached that lead occurring naturally in the soil is the main source of lead in the edible portion of the crops studied, and that airborne lead, based on the crops studied, contributes 0.5 to 1.5% of the lead content of the U.S. diet.

70-71:02I-016
RELATIONSHIP OF AUTOMOTIVE LEAD PARTICLES TO CERTAIN CONSUMER CROPS,
Schuck, E. A., and Locke, J. K.
California University, Riverside.
Environmental Science and Technology, Vol. 4, No. 4, p 324-330, April 1970.
4 fig, 9 tab, 8 ref.

Descriptors: *Crop production, *Pollution sources, Pollution effects, Lead, Air pollution.
Identifiers: Airborne lead, Soil lead.

Five crops were anlayzed for their lead content--cauliflower, tomatoes, cabbage, strawberries, and valencia oranges. In addition, the soil, water, and air in contact with these crops were analyzed for lead. The combined findings from the edible portion of four of these five crops strongly suggest that automotive lead particulates are not absorbed. They exist rather as a topical dust coating of which at least 50% can be removed by simple water washing. Neither did these crops show any inclination to absorb lead via their root systems. Similar conclusions relative to the fifth crop, i.e., strawberries, cannot be drawn except by analogy to the other crops. In spite of growing near heavily traveled highways, i.e., up to 50,000 vehicles per day, the amount of lead associated with the five crops in an untreated state was never greater than 1 microgram of Pb per gram of fresh weight. The average Pb concentration for the entire crop areas studied was one or two orders of magnitude less than 1 microgram of Pb per gram of fresh weight.

70-71:02I-017
CONTAMINATION OF ROADSIDE SOIL AND VEGETATION WITH CADMIUM, NICKEL, LEAD, AND ZINC,
Lagerwerff, J. V., and Specht, A. W.
United States Soils Laboratory, Beltsville, Maryland.
Environmental Science and Technology, Vol. 4, No. 7, p 583-586, July 1970.
2 tab, 36 ref.

Descriptors: *Crop production, *Pollution sources, Pollution effects, Lead, Zinc, Nickel, Cadmium, Air pollutio
Identifiers: Soil pollution.

Concentrations of Cd, Ni, Pb, and Zn in roadside soil and grass samples from several locations decrease with distance from traffic. These concentrations also decrease with depth in the soil profile. The contamination has been related to the composition of gasoline, motor oil, and car tires, and to roadside deposition of the residues of these materials.

70-71:02I-018
LEAD CONTAMINATION OF SOME AGRICULTURAL SOILS IN WESTERN CANADA,
John, M. K.
Canada Department of Agriculture, Agassiz, British Columbia, Canada.
Environmental Science and Technology, Vol. 5, No. 12, p 1199-1203, December 1971. 1 fig, 4 tab, 15 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, *Lead, Toxicity, Pollutants, Water pollution sources, Pollution (soil), Soil analysis.

Nitric acid soluble lead in 700 samples mostly from agricultural soils in British Columbia was related to proximity to industrial and population centers.

The soluble lead was found to be immobilized in surface horizons. Soils taken near a battery smelter were found to be highly contaminated with lead and the extent of contamination decreased with distance from the smelter.

70-71:02I-019
EFFECTS OF VARIOUS SALINITY REGIMES ON GROWTH, LEAF EXPANSION AND TRANSPIRATION OF BEAN PLANTS,
Meiri, A., and Mayber, A. P.
Volcani Institute of Agricultural Research, Israel.
Soil Science, Vol. 109, No. 1, p 26-34, January 1970. 5 fig, 5 tab, 20 ref.

Descriptors: *Soil chemistry, *Salinity, *Plant growth, Beans, Inorganic compounds, Saline soils, Soil environment, Transpiration.

Bean plants were grown under various fluctuating regimes of salinity in an attempt to simulate the field conditions prevailing in salinity-affected areas. In all experiments growth was retarded, the retardation being dependent on the rate of salinization, the ultimate level of salinity and the duration of exposure to the saline conditions. Transpiration was reduced by, and in proportion to, salinity. Transfer of plants from a saline to non-saline medium resulted in a transient burst of growth and in an increase of transpiration rate, but not to the level of the non-salinized control plants. It is concluded that the fluctuating nature of the salinity regime under normal field conditions, can be expected to affect growth and transpiration in a manner similar to, but less severe than that found in experiments carried out under conditions of constant salinity levels. The degree of retardation of growth and transpiration of plants exposed to conditions of changing salinity will be modified by the rate of salinization and the direction of the fluctuations in the salinity level of the soil.

70-71:02I-020
CROP PRODUCTION SYSTEM SIMULATION,
Stapleton, H. N.
Arizona University, Tucson.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 1, p 110-113, January 1970. 11 fig, 15 ref.

Descriptors: *Mathematical models, *Computer models, Crop production, cotton.
Identifiers: Growth simulation.

A model and the computer program for the crop subsystem is described. Attempt was made to develop a model which could be forced to provide numerical values for system effects prior to end of season yield. This information aids in the planning and decision making processes necessary to operate the farming operation. A discussion of the needed input along with the flow charts of the program is presented. In its present state the program is designed to work only with cotton.

70-71:02I-021
DESCRIPTION OF PHOTOSYNTHESIS WITHIN PLANT CANOPIES,
Duncan, W. G., and Barfield, B. J.
Kentucky University, Lexington.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5, p 960-963, May 1971. 6 fig, 6 ref.

Descriptors: *Computer models, *Crop growth, *Photosynthesis, Energy conversion, Light, Plant physiology, Transpiration.

A summary of various methods used to measure photosynthesis of growing crops in the field was presented. A review of what photosynthesis is and anologies to other man made systems were made. A model for describing and determining the rate of photosynthesis was developed. Factors affecting the process are discussed. The model can be likened to a series of snapshots taken of the processes present at a given instant. When these are all put together, a good picture of the overall process is presented. No attempt was made to simulate growth.

70-71:02I-022
DYNAMIC SIMULATION OF PLANT GROWTH--PART I. DEVELOPMENT OF A MODEL,
Curry, R. B.
Ohio Agricultural Research and Development Center, Wooster.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5,
p 946-959, May 1971. 6 fig, 1 tab, 17 ref.

Descriptors: *Mathematical models, *Computer models, *Plant growth, Evapotranspiration.

A computer model for plant growth was developed. Objectives of the work were: (1) To develop a model that is a dynamic simulation of plant growth. (2) To account for the total energy of the system. (3) The program should be developed in individual parts so that as methods are improved, it can be easily updated. The model and data presented are first approximations of a possible dynamic modeling approach to the plant growth system. The program is written in continuous system modeling program language which was found quite adequate. The assumptions required were many and they should all be critically reviewed in the laboratory and field to validate them.

SECTION X

WATER CYCLE

EROSION AND SEDIMENTATION (Group 02J)

70-71:02J-001
SOIL ERODIBILITY AS AFFECTED BY SOIL SURFACE PROPERTIES,
Epstein, E., and Grant, W. J.
Agricultural Research Service, Orono, Maine, Soil and Water Conservation Research Division.
American Society of Agricultural Engineers Transactions, Vol. 14, No. 4, p 647-648, 655, July-August 1971. 7 fig, 2 tab, 10 ref.

Descriptors: *Soil erosion, *Simulated rainfall, *Surface runoff, *Impact (Rainfall), *Soil surfaces, Soil compaction, Surface sealing, Hydraulic models, Laboratory tests.
Identifiers: *Soil crusts.

Erodibility of soils is related to the changes in soil surface properties resulting from rainfall. After 10 minutes of applied artificial rainfall, the soil loss at different kinetic energies remained constant at a rate of 625 g per joule per sq cm. This is caused by shearing of a thin layer, accompanied by the continual formation of a consolidated seal. The seal and underlying crust are mainly due to the physical impact of raindrops. There were no discernible changes in soil texture below the 0.5-mm region of the crust.

70-71:02J-002
PLANT COVER, RUNOFF, AND SEDIMENT YIELD RELATIONSHIPS ON MANCOS SHALE IN WESTERN COLORADO.
Branson, F. A., and Owen, J. B.
Geological Survey, Denver, Colorado.
Water Resources Research, Vol. 6, No. 3, p 783-790, June 1970. 8 p, 6 fig, 1 tab, 18 ref.

Descriptors: *Soil-water-plant relationships, *Rainfall-runoff relationships, *Sediment yield, Geomorphology, Topography, Correlation analysis, Drainage patterns (Geologic), Drainage density, Runoff forecasting, Hydrograph analysis, Streamflow forecasting, Colorado.
Identifiers: Plant cover-runoff-sediment yield relations, Grand Junction (Colorado).

Relationships between vegetation and hydrologic measurements for 17 watersheds near Grand Junction, Colorado, were subjected to correlation analyses. Six years of vegetation measurements, four vegetation measurement methods, and fifteen years of hydrologic records were used in the analyses. Highly significant correlation coefficients were found for percent bare soil and runoff, but the relationships between bare soil and sediment yields were not statistically significant. Geomorphic parameters such as angle of junction, mean slope, drainage density, relief ratio, length-width ratio, and watershed area were more highly correlated with sediment yields than with runoff. Correlation coefficients for spring vegetation measurements and runoff were higher than for autumn measurements. First contact methods and step point vegetation measurement methods were superior to the loop method and the all contacts point method. Curves for the relationship of runoff to bare soil were strikingly different for three sets of watersheds from different precipitation zones. Bare soil measurements may provide rapid and inexpensive estimates of runoff for watersheds similar to the ones studied.

70-71:02J-003
IOWA PASSES EROSION-CONTROL LAW,
Moon, W. T.
Soil Conservation Service, Des Moines, Iowa.
Soil Conservation, Vol. 36, No. 12, p 272-273, 1971.

Descriptors: Soil erosion, Land management, Erosion control, Soil management legislation.
Identifiers: Iowa.

A new law - described as the most far-reaching soil conservation law in the country - went into effect on July 1. The law is called a conservancy district law. It sets up six conservancy districts, which take in the entire state, on a watershed basis to coordinate efforts of drainage districts and soil conservation districts and to help put into effect the comprehensive statewide water-resources plan. It requires that landowners, urban and rural, whose soil loss exceeds certain limits employ erosion-control measures. Landowners are to be given time to reduce erosion to an acceptable level. The objective of the law is to stop erosion by any means.

SECTION XI

WATER CYCLE

CHEMICAL PROCESSES (Group 02K)

70-71:02K-001
GEOCHEMICAL INTERPRETATIONS OF GROUNDWATER FLOW SYSTEMS,
Back, W., and Hanshaw, B. B.
Geological Survey, Washington, D.C.
Water Resources Bulletin, Vol. 7, No. 5, p 1008-1016, October 1971. 5 fig, 12 ref.

Descriptors: *Geochemistry, *Hydrogeology, *Reviews, Groundwater movement, Saline water intrusion, Path of pollutants, Drawdown, Water levels, Aquifer characteristics, Water quality, Water yield, Thermodynamics, Carbonate rocks.
Identifiers: Groundwater flow systems.

This brief review describes several of the chemical and isotopic techniques which are being applied to groundwater flow systems. Geochemical techniques used to facilitate the understanding of a groundwater system range from extremely simple to those requiring sophisticated theories, equipment, and procedures. An interpretation of the trilinear diagram for samples collected from the Yucatan Peninsula of Mexico provided evidence that the fresh-water body was only a few tens of meters thick and was underlain everywhere by an extensive body of salt water. A geochemical technique to identify the source of salt water in coastal aquifers is measurement of the carbon-14 concentration. Carbon-14 may be used in carbonate aquifers to determine the velocity of groundwater movement, rates of chemical reactions, and distribution of hydraulic conductivity. The principles of irreversible thermodynamics applied to groundwater systems provide a basis for prediction of changes in head distribution and chemical character of the water resulting from imposed stresses on the system. Proper application of irreversible thermodynamics combines potential theory with principles of reversible chemical thermodynamics to explain chemical reactions and processes of groundwater systems.

70-71:02K-002
A WATER QUALITY MODEL OF CHLORIDES IN GREAT LAKES,
O'Connor, Donald J., and Mueller, John A.
Manhattan College, Bronx, New York. Department of Civil Engineering.
ASCE Proceedings, Journal of the Sanitary Engineering Division, Vol. 96, No. SA4, Paper 7470, p 955-975, August 1970. 14 fig, 6 tab, 23 ref, append.

Descriptors: *Water quality, *Great Lakes, *Chlorides, *Salt balance, *Mathematical models, Water balance, Streamflow, Hydrologic budget.
Identifiers: Water quality models.

The increase in the concentration of conservative substances in the Great Lakes is described by a simple time variable equation. The concentration of chlorides is related to the fresh water flow, the volumes of the lakes and the various sources--municipal, industrial, natural background and road deicing. The increase in concentration since 1900 is presented and projections are made of anticipated concentrations based on various assumptions of control.

70-71:02K-003
DISPERSION OF NATURALLY OCCURRING IONS IN GROUNDWATER FROM VARIOUS ROCK TYPES IN A PORTION OF THE SAN PEDRO RIVER BASIN, ARIZONA,
Wallace, D. E., and Cooper, L. R.
Agricultural Research Service, Tucson, Arizona, Southwest Watershed Research Center.
Journal of Hydrology, Vol. 10, No. 4, p 391-405, June 1970. 15 p, 9 fig, 1 tab, 7 ref.

Descriptors: *Groundwater movement, *Water chemistry, *Dispersion, *Tracers, *Arizona, Solutes, Alluvium, Recharge, Discharge (Water), Flow nets, Leaching, Mixing, Ion transport, Ions.
Identifiers: San Pedro River basin (Arizona).

The groundwater in an alluvial basin in southern Arizona was analyzed for concentrations of Ca, Mg, Na, and Cl ions. The variety of rock types in the area, plus the undisturbed state of the groundwater basin, made comparative rock mineralization-groundwater ionization interpretations possible. Ionic dispersion in groundwater emanating from source areas composed of differing rock types is plotted as isogram maps. These isolated areas of differing mineral composition each exhibit a unique ionic contribution to groundwater. The ion concentration in groundwater were then used as naturally occurring tracers to determine source areas of recharge and to delineate subsurface barriers to the normal basin flow net. Ion dispersion plots reveal the carbonates of the Dragoon Mountains to be a major contributor of Ca and Mg to the deep alluvial portion of the basin. Cl dispersion patterns show the granitic intrusives of the Tombstone Hills produce a barrier effect in the normal flow pattern of the basin as well as being a contributor of Cl to groundwater.

70-71:02K-004
DISSOLVED SOLIDS-DISCHARGE RELATIONSHIPS: 1. MIXING MODELS,
Hall, Francis R.
New Hampshire University, Durham.
Water Resources Research, Vol. 6, No. 3, p 845-850, June 1970. 6 p, 1 fig, 7 ref.

Descriptors: *Water quality, *Streamflow, *Dissolved solids, *Mathematical models, Aqueous solutions, Solutes, Mixing, Leaching, Dispersion, Diffusion, Discharge (Water).
Identifiers: Discharge-dissolved solids relationships, Mixing models.

A reasonable basis is needed for the selection of models to aid in analyzing the relationships between dissolved constituents and discharge in streams. A series of simple mixing models based on mass balance calculations is presented along with derivations and solutions for assumptions about the mixing volumes and the storage volume-discharge relationship. If concentration and discharge data show a hysteresis or loop relationship with time, then the commonly assumed direct relationship between total volume of water in the stream channel and stream discharge is probably not valid. The relationship of the constants in the derived equations to physical or chemical factors is masked at the present time by the nature of the initial assumptions and the method of derivation.

70-71:02K-005
DRY MATTER PRODUCTION AND NUTRIENT UPTAKE IN IRRIGATED COTTON (GOSSYPIUM HIRSUTUM),
Bassett, D. M., Anderson, W. D., and Werkhoven, C. H. E.
California University, Davis. Department of Agronomy and Range Science.
Agronomy Journal, Vol. 62, No. 2, p 299-303, 1970. 4 fig, 9 ref.

Descriptors: *Nutrient removal, *Chemical analysis, *Distribution, Cotton, Irrigation, Crop production.
Identifiers: Cotton (Gossypium hirsutum), San Joaquin Valley of California, Seasonal uptake.

Dry-matter production of cotton (Gossypium hirsulum L.) plants in the irrigated San Joaquin Valley of California was slow for 40 to 80 days following seeding, with only 2 to 4 percent of the total season aerial dry matter present at time of first square, and 7 to 10 percent at time of first flower (one-fourth to one-tenth of the percentages reported elsewhere for these stages). One-third of the total seasonal dry matter was produced in a 2-week period in August. Total dry matter ranged from 6,900 to 8,900 kg/ha, distributed in mature plants as stems, 23.1 percent; leaves, 17.4 percent; burs, 16.3 percent; seed, 25.3 percent; and lint, 17.9 percent. The proportion of lint was at least 50 percent higher than reported from early research in other areas. Amounts of N, P, K, Ca, Mg, and Na accumulated in the aboveground parts at first flower were less than 15 percent of the final amounts. Of total seasonal uptake, 45 percent of N and P occurred in July and 67 percent of K in the 6 weeks beginning July 1. During these peak absorption periods, daily uptake per hectare was 1.5 to 2.0 kg N, 0.17 to 0.34 kg P, and 2.1 to 3.4 kg K. Mature plants contained 142 kg N, 19 kg P, and 127 kg K per hectare. About 70 kg N, 11 kg P, and 21 kg K per hectare were contained in the seed. The amount of dry matter needed to produce 100 units lint contained 10 units N, 1.5 P, and 9 K. More than half of the N and P was in seed, and more than one-third of the K was in the bur.

70-71:02K-006
PREDICTION OF THE NITROGEN REQUIREMENTS OF FIELD CROPS. PART I. THEORETICAL MODELS OF NITROGEN RELEASE,
Reuss, J. O., and Geist, J. M.
Colorado State University, Fort Collins. Department of Agronomy.
Agronomy Journal, Vol. 62, No. 3, p 381-384, 1970. 5 ref.

Descriptors: *Model, *Nitrogen, Soil testing, Fertilizer.
Identifiers: Multiple regression, Nitrogen release.

Theoretical models for the prediction of the total supply of mineral nitrogen available for crop production have been developed. These models are based on the assumption that the supply of available N is determined by fertilizer N, native soil mineral N, and N released from organic matter. Model No. (1) is of the form $Y = b_0 + b_1X_1 + b_{11}X_1^2 + b_2X_2 + b_{22}X_2^2 + b_{12}X_1X_2$, where: Y = yield or other parameter dependent on N supply, X_1 = fertilizer N plus available soil mineral N, X_2 = any index of organic N release, and b_1, b_2, b . . . are coefficients determined by regression techniques. Model No. (2) is of the form $Y = B_0 + B_1(X_1 + aX_2) + B_2(X_1 + aX_2)^2$, where: a represents a release coefficient appropriate to a given X_2: B_0, B_1, B_2 are regression coefficients; and Y, X_1, and X_2 are the same as in Model (1). The release coefficient a can be evaluated by ratios of slopes from Model (1), or by a reiterative procedure. More sophisticated models based on Model (2), but assuming nonlinear release of organic N, have also been developed along with methods for evaluating the constants involved.

70-71:02K-007
PREDICTION OF NITROGEN FERTILIZER REQUIREMENTS OF FIELD CROPS. II. APPLICATION OF THEORETICAL MODELS TO MALTING BARLEY,
Geist, J. M., Reuss, J. O., and Johnson, D. D.
Pacific Northwest Forest and Range Experiment Station, La Grande, Oregon.
Agronomy Journal, Vol. 62, No. 3, p 385-389, 1970. 3 tab, 3 fig, 11 ref.

Descriptors: *Nitrogen, *Model, Soil testing, Fertilizer, Barley.
Identifiers: Prediction model, Moravian barley, Nitrogen availability, Moravian barley (Hordeum distichum L. emend. Lam.).

Five indices of soil organic nitrogen availability and mineral plus fertilizer nitrogen were used in the prediction of grain yield, grain protein content, and grain protein nitrogen of Moravian barley. Three mathematical models were employed, one of which included only soil mineral plus fertilizer N for prediction of crop parameters. The remaining two models, which included both organic and mineral plus fertilizer N showed improved predictability of crop parameters. No organic nitrogen measure showed superiority to others, however, one equation model was advantageous in studying the relative contribution of soil organic N to crop production.

70-71:02K-008
EFFECT OF A PLASTIC BARRIER UNDER THE NITRATE BAND ON NITROGEN UPTAKE BY PLANTS,
Parks, C. L., White, A. W., and Boswell, F.

Agricultural Research Service, Watkinsville, Georgia.
Agronomy Journal, Vol. 62, No. 4, p 437-439, 1970. 5 tab, 14 ref.

Descriptors: Nitrogen, Barrier, Fertilizer, Soil management.
Identifiers: *Nitrogen uptake, *Plastic barrier, Nitrogen application, Corn (Zea mays L.), Rye (Secale cereale).

Field experiments were conducted on a Cecil sandy loam (Typic Hapludults) to test the effectiveness of a physical barrier (plastic trough) placed immediately beneath a band of nitrate fertilizer in preventing loss of fertilizer N from the root zone by leaching, as measured by plant growth and N uptake. Rye (Secale cereale) and corn (Zea mays) were used as test plants to evaluate the effect of the physical barriers upon fall and spring applied N. A split plot design was used for each experiment. Rye was harvested in December, March, and when the grain was in the dough stage. Eight corn plants were harvested from each plot 30, 37, 44, 52, 65, and 88 days after plant emergence. The total N content of plant samples taken at each harvest date was determined. The applied N recovered in the rye forage was 76, 63, and 47 percent for the 45, 90, and 180 kg/ha rates of N, respectively. The applied N recovered in the corn grain was 33, 25, and 20 percent for the 68, 136, and 272 kg/ha rates of N, respectively. Placing a physical barrier immediately beneath the fertilizer band did not significantly ($P<0.05$) increase the uptake of N by the plants or the plants' recovery of the fertilizer N.

70-71:02K-009

NITROGEN MOVEMENT COMPARISONS IN CROPPED VERSUS FALLOWED SOILS,

Boswell, F. C. and Anderson, O. E.
Georgia University, Agriculture Experiment Stations, Georgia Station, Experiment, Georgia.
Agronomy Journal, Vol. 62, No. 4, p 499-503, 1970. 3 tab, 4 fig, 18 ref.

Descriptors: *Nitrogen, *Soil properties, Leaching, Fallowing, Soil management.
Identifiers: Nitrogen movement, Nitrogen recovery, Nitrogen accumulation.

The movement and accumulation patterns of N, applied as KNO_3 to cropped and fallowed plots, were studied on two widely different soils, Marlboro and Davidson. Generally, the movement and accumulation patterns indicated movement of N to a greater depth and extent on the cropped than on fallowed plots. Nitrogen movement in the Marlboro surface and subsoil was considerably greater than in Davidson soil. Even with excessive rainfall, most of the N recovered 11 to 12 months after application was concentrated between the 46- to 122-cm depths with the largest accumulation occurring in the 61- to 91-cm layer. After 10 weeks and 29 cm of rainfall, 78 percent of the applied N was recovered on the fallowed Davidson soil while after 50 weeks and 154 cm of rainfall 53 percent was recovered. Comparable recoveries for the cropped plots were 99 and 49 percent respectively. After 5 weeks and 12 cm rainfall, the recovery on the fallowed plots of the Marlboro soil was 109 percent but had decreased to 33 percent after 46 weeks and 124 cm of accumulated rainfall. Data for cropped plots indicated 119 and 25 percent recovery for the respective sampling periods. Recovery increased approximately 5 to 10 percent on the cropped plots when the plant N uptake values were included.

70-71:02K-010

OXYGEN DIFFUSION IN THE SOIL-PLANT SYSTEM. IV. OXYGEN CONCENTRATION PROFILES, RESPIRATION RATES, AND RADIAL OXYGEN LOSSES PREDICTED FOR RICE ROOTS,

Luxmoore, R. J., Stolzy, L. H., and Letey, J.
California University, Riverside, Dept of Soils and Plant Nutrition.
Agronomy Journal, Vol. 62, No. 3, p 329-332, 1970. 3 tab, 6 fig, 9 ref.

Descriptors: *Respiration, *Oxygen, Rice, Root system.
Identifiers: Oxygen concentration profiles, Respiration rate, Radial loss, Oxygen diffusion, Rice root model, Root radius, Rice (Oryza sativa L.).

Oxygen concentration profiles, mean respiration rates, and the percent radial oxygen losses (proportion of the oxygen diffusing into the top of the root that is lost radially from the root) were obtained from an analysis of steady state oxygen diffusion in rice (Oryza sativa L.) root models under simulated paddy field conditions. An increase in root radius and water layer thickness results in an increase in the oxygen concentration within the root and at the root wall at all positions along the root. These higher oxygen concentrations resulted in higher mean respiration rates, however, the percent radial oxygen loss (PRL) was reduced. The mean respiration rate and PRL were both decreased with increase in root length. Under paddy conditions it seems that oxygen concentration is a factor limiting respiration rate since the mean respiration rate is much less than the maximum rate for mature root tissue. A 20-cm root with a 0.05-cm radius is predicted to radially lose about 5 to 7 percent of the oxygen diffusing into the top of the root. This has considerable ecological significance for roots growing in an anaerobic medium.

70-71:02K-011
OXYGEN DIFFUSION IN THE SOIL-PLANT SYSTEM. II. RESPIRATION RATE, PERMEABILITY, AND POROSITY OF CONSECUTIVE EXCISED SEGMENTS OF MAIZE AND RICE ROOTS,
Luxmoore, R. J., Stolzy, L. H., and Letey, J.
California University, Riverside, Dept of Soils and Plant Nutrition.
Agronomy Journal, Vol. 62, No. 3, p 322-324, 1970. 2 tab, 3 fig, 11 ref.

Descriptors: *Respiration, *Root system, *Oxygen, *Diffusion, Permeability, Porosity.
Identifiers: Maize (Zea mays L.), Rice (Oriza sativa L.), Oxygen concentration, Pycnomometer method, Root respiration.

Respiration rates were determined at 4.4, 20.8, and 80 percent oxygen concentration for consecutive excised segments of maize (Zea mays L.) and rice (Oriza sativa L.) roots. From these data, the maximum respiration rate, the oxygen concentration at which respiration was half of the maximum rate, and the root permeability to oxygen were derived for each position along the root, up to 10 cm from the root tip for maize and 6 cm for rice. The gas-filled porosity of these segments was measured by the pycnometer method. The root tip segment is characterized by the highest maximum respiration rate, highest permeability, and lowest porosity. Both respiration rate and permeability decrease with distance from the root tip, whereas porosity increases to a maximum of 10 percent for maize and 33 percent for rice. The oxygen concentration at which respiration is half of the maximum rate is about 8 percent for maize and about 16 percent for rice at each position along the root.

70-71:02K-012
OXYGEN DIFFUSION IN THE SOIL-PLANT SYSTEM. I. A MODEL,
Luxmoore, R. J., Stolzy, L. H., and Letey, J.
California University, Riverside. Dept of Soils and Plant Nutrition.
Agronomy Journal, Vol. 62, No. 3, p 317-322, 1970. 4 fig, 10 ref, 1 append.

Descriptors: *Aeration, *Respiration, *Diffusion, Computer analysis, Model, Oxygen.
Identifiers: Plant aeration, Soil aeration, Root respiration, Steady state model, Oxygen diffusion.

A model for steady state, isothermal oxygen diffusion into a cylindrical root surrounded by a water film of uniform thickness is proposed. Equations are developed which account for longitudinal oxygen flux through the intercellular gas spaces, radial flux through the water film, and a respiratory oxygen sink which is defined as a function oxygen concentration. A method of computer analysis is outlined whereby the law of continuity is applied sequentially to small sections of root, such that the amount of oxygen diffusing into a section is equated with the oxygen diffusing out plus the respiratory consumption. The solution for the model defines a series of oxygen concentrations along the root length. From these data the amount of oxygen consumed in respiration which diffuses into the top of the root (plant aeration) and the amount diffusing radially from the soil (soil aeration) may be calculated, and effect of soil and plant characteristics examined.

70-71:02K-013
EFFECTS OF SHORT PERIODS OF ANAEROBIC AND NEAR-ANAEROBIC CONDITIONS ON WATER UPTAKE BY TOBACCO ROOTS,
Willey, C. R.
North Carolina State University, Raleigh, Dept of Biological and Agricultural Engineering.
Agronomy Journal, Vol. 62, No. 2, p 224-229, 1970. 2 tab, 9 fig, 19 ref.

Descriptors: *Aeration, *Absorption, Drainage, Biological uptake roots, Tobacco.
Identifiers: Root respiration, Anaerobic treatment, Tobacco (Nicotiana tabacum L.).

Intact tobacco roots growing in nutrient solution spray in a sealed chamber were treated with mixtures of O_2, N_2, and CO_2 gases. Oxygen and water uptake by roots and plant stem diameter were recorded. Anaerobic treatments produced by flushing roots with N_2 or N_2 plus 21 percent CO_2 gases for 6 hours decreased water uptake 50 percent or more, but restoration of air to roots caused a rapid recovery of water uptake. Root injury was caused by both treatments as evidenced by reduced oxygen uptake following each treatment. Gases with 1 percent or more oxygen had little or no effect on water uptake. Treatment gases containing up to 21% CO_2 had the same effect on water uptake as treatment gases without CO_2. Oxygen deficiency appears to be the primary cause of the initial decrease in water uptake and wilting of tobacco subjected to poor root aeration.

70-71:02K-014
SOIL TEMPERATURE AND SOURCE OF NITROGEN IN RELATION TO NITRIFICATION IN SODDED AND CULTIVATED SOILS,
Anderson, O. E., Jones, L. S., and Boswell, F. C.
Georgia University, Experiment, College of Agriculture, Experiment Stations, Georgia Station.
Agronomy Journal, Vol. 62, No. 2, p 206-211, 1970. 2 tab, 6 fig, 11 ref.

Descriptors: Nitrification, Incubation, Soil temperature, Rotation.
Identifiers: Nitrogen recovery, Nitrogen inhibition.

Sods of coastal bermudagrass and fescue in permanent pastures or in sod-based rotations did not greatly inhibit nitrification of applied N at 32 deg C. Nitrification was strongly inhibited by sods in the finer textured soils at 6 deg C, especially those high in silt content. Though there were differences in nitrification rates among several sources of N, they were not strongly related to cropping practices. There were wide differences among the various N sources in the percent recovery of applied N. The percent recovery at 32 deg C was always higher in sodded than in cultivated soils, irrespective of source, but at 6 deg C the effect of cropping practice was inconsistent.

70-71:02K-015
RESPONSE OF COTTON TO BORON,
Murphy, B. C., and Lancaster, J. D.
Mississippi Agricultural Experimental Station, Dept of Agronomy.
Agronomy Journal, Vol. 63, No. 4, p 539-540, 1971. 3 tab, 1 fig, 9 ref.

Descriptors: *Boron, *Crop response, Cotton, Foliar application, Application method.
Identifiers: Soil content, Plant content, Critical boron level.

Field experiments were conducted with rates and methods of application of B to cotton. Broadcast was as effective as drilled, foliar application was as good as soil application, and there was no advantage to a combination of soil and foliar application. A highly soluble source of B was superior to a more slowly soluble one. Young leaves, the third or fourth node from the growing point, were found to have a critical level of about 15 ppm B. Mature leaves occurring at the fifth and sixth nodes from the growing point had a B content of 5 to 10 ppm higher. The critical level of hot-water soluble B in the top 15 cm of soil was in the range of 0.10 to 0.16 ppm.

70-71:02K-016
NITROGEN RELEASE FROM SULFUR-COATED UREA, AS AFFECTED BY COATING WEIGHT, PLACEMENT AND TEMPERATURE,
Allen, S. E., Hunt, C. M., and Terman, G. L.
National Fertilizer Development Center, TVA, Muscle Shoals, Alabama.
Agronomy Journal, Vol. 63, No. 4, p 529-533, 1971. 1 tab, 6 fig, 5 ref.

Descriptors: *Nitrogen, Incubation, Temperature.
Identifiers: Nitrogen release, Bermudagrass (Cynadon dactylon), Sulfur-coated urea.

Greenhouse and laboratory studies were conducted to measure the factors controlling release of N from sulfur-coated urea (SCU). Results of two greenhouse pot experiments with common bermudagrass (Cynodon dactylon) and a third with uncropped soil in controlled environment regimes showed that the rate of dissolution of SCU increased greatly with higher temperatures of cropping or incubation. Dissolution rates of SCU granules were decreased by heavier coating with S, by inclusion of 0.5 percent coal tar oil microbicide in the coating, and by surface application, as compared to mixing with the soil. Satisfactorily coated urea (SCU) or split applications of uncoated ammonium nitrate (AN) or urea both resulted in more uniform distribution of forage production and N uptake than did a single application of urea of AN at time of seeding. Greater yields of forage were obtained from single applications of some SCU products than from urea or AN. Apparent volatilization losses of surface-applied urea were severe, particularly at higher growth, or incubation temperatures. Losses of N were reduced, but not entirely eliminated by S-coating.

70-71:02K-017
A BIOLOGICAL METHOD FOR EVALUATING SOIL NITROGEN AVAILABILITY AND FORECASTING NITROGEN FERTILIZER NEEDS OF WHEAT,
Amir, J., and Ephrat, J.
Volcani Institute of Agricultural Research, Bet Dagan, Israel, Dept of Agronomy.
Agronomy Journal, Vol. 63, No. 3, p 385-388, 1971. 2 tab, 3 fig, 23 ref.

Descriptors: Fertilizer, Wheat, Nitrogen, Absorption.
Identifiers: Wheat (Triticum aestivum L.), Nitrogen uptake, Nitrogen fertilization, Wheat fertilization, Soil nitrogen availability.

A biological method for evaluating N availability and forecasting N fertilizer needs of wheat (Triticum aestivum L.) is proposed. Spring wheat plants were grown in containers with 8 kg of soil from the field under consideration. Total N uptake, as determined 60 days after sowing (at the beginning of heading). indicated the potential response of the wheat crop in the field. The test of the method's suitability for practical use was based on the response of the wheat crop to N application in the field. The total N (in milligrams) taken up by the test plants was designated as the nitrogen index of the soil (NI). On the mineral loess soils of the semi-arid Israeli Negev, wheat responded significantly to N fertilization only in fields with NI lower than 100.

70-71:02K-018
THE DISTRIBUTION OF NITRIFYING BACTERIA IN SOIL AGGREGATES,
Nishio, M. and Furusaka, C.

Tohoku University, Sendai, Japan. Institute for Agricultural Research.
Soil Science and Plant Nutrition, Vol. 16, No. 1, p 24-29, 1970. 5 fig, 11 ref.

Descriptors: *Bacteria, *Percolation, Soil aggregates, Distribution.
Identifiers: Sonic vibration method, Washing method, Nitrifying bacteria.

The distribution of nitrifying bacteria in soil aggregates, which were percolated with ammonium or nitrate, was studied using the "washing and sonic vibration method." In air-dried aggregates most of nitrifying bacteria were observed to be present in the inner-fraction. Treated with percolation, nitrifying bacteria in the outer-fraction increased more vigorously than those in the inner-one. When the percolated aggregates were desiccated over P_2O_5 or treated with $HgCl_2$ solution, the bacteria in the outer-fraction were killed more easily than those in the inner-fraction. These results are well explained as in the case of heterotrophic bacteria by the concept that an aggregate as a habitat of bacteria can be divided into 2 distinct sites, i.e., the inner and the outer-site.

70-71:02K-019
SOME CHEMICAL PROPERTIES OF SOILS FROM AREAS OF BARLEY GRASS (HORDEUM MURINUM L.) INFESTATION,
Metson, A. J., Saunders, W. M. H., and Nott, J. H.
Soil Bureau, Lower Hutt, New Zealand, Dept of Scientific and Industrial Research.
New Zealand Journal of Agricultural Research, Vol. 14, No. 2, p 334-351, 1971. 7 tab, 33 ref.

Descriptors: *Salinity, *Soil analysis, Chemical analysis, Nutrients.
Identifiers: Hawke's Bay district, Barley grass, Soluable salt content.

Chemical analyses of soils (0-1 in) under pastures in the Hawke's Bay district showing heavy (H), moderate (M), or light (L) infestations of barley grass (Hordeum murinum L.) showed values for Truog P. organic C, total N, and exchangeable Ca, Mg, K, and HH_4 in the order H>M>L. Concentrations of total soluble salts were also in the order H>M>L, and the order of abundance of individual ions was: for cations, $K^+>Ca^{2+}>Mg^{2+}>Na^+$; for anions, $HCO_3^->NO_3^->Cl^->SO_4^2$. The results were consistent with the hypothesis that invasion of pastures by barley grass is favored by the development of saline areas and urine at sites where stock congregate. It is suggested that with continued camping of stock, sites in low-rainfall districts at present heavily infested with barley grass may eventually be superseded by bare ground because of increasing soil salinity. Seed counts on soils (sampled in March) give Hordeum counts in the order H>M>L. Germination tests on the same soils showed seedling emergence for different species as follows: Hordeum marinum, H>M>L; other grasses, H<L<M; clovers, H<M<L; weeds, H>L>M.

70-71:02K-020
THE MEASUREMENT AND MECHANISM OF ION DIFFUSION IN SOILS V. DIFFUSION OF HYDROGEN ION IN SOILS,
Farr, E., Vaidyanathan, L. V., and Nye, P. H.
Oxford University, Aberdeen, School of Agriculture, Dept of Chemistry and Biochemistry.
The Journal of Soil Science, Vol. 21, No. 1, p 1-14, 1970. 2 tab, 8 fig, 2 append, 18 ref.

Descriptors: *Diffusion, *Cation exchange, Ions, Hydrogen, Calcium.
Identifiers: Flux, Buffer.

The linear diffusion of H ion from a series of soil blocks, containing essentially H and Ca only as exchangeable cations, into a sink solution maintained at pH 5.2 has been studied. In three separate series of experiments, first the total concentration of diffusible H, then the amount of diffusible H in the pore solution, and finally the amount of exchangeable H associated with the solid phase have been successively varied. The effect of the resulting flux and diffusion coefficients of the ion has been related to the H buffer power of the soil. The impedance factor of the ion through the liquid pathway is slightly lower than that for other cations determined in soil. The diffusive flux of H occurs through the liquid pathway, and the contribution of solid-associated H is small, except possible at low H ion solution concentrations.

70-71:02K-021
A MODEL OF A GROWING PASTURE,
Paltridge, G. W.
Commonwealth Scientific and Industrial Research Organization, Aspendale, Victoria, Australia, Division of Meteorological Physics.
Agricultural Meteorology, Vol. 7, No. 2, p 93-130, 1970. 4 tab, 12 fig, 1 append, 25 ref.

Descriptors: Model, Growth, Vegetation, Pasture.

An attempt is made to model a developing pasture in a manner requiring an experimental data on dependent variables. The term "pasture" here includes all forms of uniform vegetation which can be characterized primarily by leaves and roots. The model is based on the concept of limiting values. At any time at a particular level in the canopy, growth is determined by one of three parameters (radiation available, carbon dioxide available, or the capacity of individual leaves to carry out the photosynthetic conversion) which are calculable from the defined above-crop external conditions and the parameters of the plant which have been selected as independent. Because the model does not rely on field data, it is possible to use simple evolutionary constraints to enable the pasture to generate its own architecture as the photo-synthesized material becomes available. Soil water status is included, so that the effect of water deficit on the growth pattern of both leaves and roots can be investigated. The most obviously useful agrometeorological concepts have been incorporated, so that for a particular simulation attempt it is only necessary to devise suitable physical descriptions of leaf shape and orientation. Illustrative trials of the model compare well (in those aspects where comparison is possible without direct simulation) with real pastures, and reveal behavior-patterns which may help to direct experimental research in the field.

70-71:02K-022
OXYGEN DIFFUSION IN THE SOIL-PLANT SYSTEM III. OXYGEN CONCENTRATION PROFILES, RESPIRATION RATES, AND THE SIGNIFICANCE OF PLANT AERATION PREDICTED FOR MAIZE ROOTS,
Luxmoore, R. J., Stolzy, L. H., and Letey, J.
California University, Riverside, Dept of Soils and Plant Nutrition.
Agronomy Journal, Vol. 62, No. 3, p 325-329, 1970. 3 tab, 7 fig, 16 ref.

Descriptors: Oxygen, Diffusion, Respiration, Root system, Aeration.
Identifiers: Maize (Zea mays L.), Maize root model.

Oxygen concentration profiles, mean respiration rates, and the percent plant aeration estimates (proportion of respired oxygen diffusing from the atmosphere via gas spaces in the plant) were obtained from an analysis of steady state oxygen diffusion in maize (Zea mays L.) root models under simulated field conditions. An increase in root radius and in water film thickness as occurs after rainfall or irrigation induced a decrease in oxygen concentration within the root, a decrease in mean respiration rate, and an increase in percent plant aeration (PPA). An increase in root length reduced both mean respiration rate and PPA. Plant aeration is predicted to be a significant factor in the oxygen relations of maize roots. For a given root system, the gas-filled porosity and the thickness of the water film around the root have the greatest influence on this process. Soil aeration is important in the oxygen supply to the lower root and root tip regions and this has a critical effect on continuing plant growth and development.

70-71:02K-023
DIFFERENTIAL RESPONSE OF RICE VARIETIES TO TIMING OF MID-SEASON NITROGEN APPLICATIONS,
Wells, B. R., and Johnston, T. H.
Arkansas University, Stuttgart, Crops Research Division, Agricultural Research Service, U.S. Dept of Agriculture; and Arkansas Agricultural Experiment Station,
Agronomy Journal, Vol. 62, No. 5, p 608-611, 1970. 8 tab, 5 ref.

Descriptors: *Nitrogen, *Application rate, *Crop response, Rice.
Identifiers: Plant type, Lodging, Rice yield, Grain weight, Rice (Oryza Sativa L.)

Field studies were conducted with rice (Oryza sativa L.) on Crowley silt loam soil using the important commercial cultivars 'Bluebell,' 'Nova 66,' and 'Starbonnet.' Studied were the effects of rate and timing of mid-season N applications on grain yield, plant height, lodging, headrice yield, and grain weight (g/M) of varieties (cultivars) differing in maturity and plant type. Maximum grain yields were associated with N applied at median internode lengths averaging 21.0, 58.5, and 5.0 mm for Bluebelle, Nova 66, and Starbonnet, respectively. Delaying mid-season N applications until these respective stages of plant development, resulted in shorter plants and less lodging, accompanied by increased grain weight and head-rice yields. Variations in the median internode length at N fertilization, timed for a combination of maximum grain yield and minimum plant height and lodging, were closely associated with plant type. Starbonnet and Bluebelle, which have short, stiff straw and erect leaves, responded better to N applied at a shorter internode length than Nova 66, a taller, broader-leaved variety. When N was applied too early, Nova 66 produced considerably more excessive vegetation than did Bluebelle and Starbonnet. Both Starbonnet and Bluebelle have plant types which approach the one currently favored by many plant breeders.

70-71:02K-024
THE MEASUREMENT AND MECHANISM OF ION DIFFUSION IN SOILS VI. THE EFFECT OF CONCENTRATION AND MOISTURE CONTENT ON THE COUNTER-DIFFUSION OF SOIL PHOSPHATE AGAINST CHLORIDE ION,
Farr, E., Vaidyanathan, L. V., and Nye, P. H.
Oxford University, Aberdeen, School of Agriculture, Department of Chemistry and Biochemistry, Soil Science Laboratory.
The Journal of Soil Science, Vol. 21, No. 1, p 15-27, 1970. 4 tab, 3 fig, 14 ref.
(See 70-71:02G-061)

70-71:02K-025
ISOTOPIC EXCHANGE STUDIES OF MICRONUTRIENTS IN SOILS,
Lopez, P. L., and Graham, E. R.
Missouri University, Columbia.
Soil Science, Vol. 110, No. 1, p 24-30, July, 1970. 4 tab, 16 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, *Soil management, Soil structure, Groundwater.
Identifiers: *Micronutrients, *Soil fertility.

Three soil samples of Mexico silt loam with pH of 5.0, 6.6, 7.4 were used. The equilibrium concentration in solution and the reserve amounts in the solid phase of Mn, Fe, Zn, and Cu were determined by isotopic exchange. The labile pool of each element was calculated from these values. Factors affecting the determination, such as pH of the soil and the extractant, drying treatments, composition of extraction solutions, and equilibration time to reach a steady state were included.

70-71:02K-026
CALCULATION OF ELECTRICAL CONDUCTIVITY FROM SOLUTION COMPOSITION DATA AS AN AID TO IN-SITU ESTIMATION OF SOIL SALINITY,
McNeal, B. L., Oster, J. D., and Hatcher, J. T.
United States Department of Agriculture, Riverside, California, Agricultural Research Service, Soil and Water Conservation Research Division, United States Salinity Laboratory.
Soil Science, Vol. 110, No. 6, p 405-414, December 1970. 2 fig, 6 tab, 12 ref.

Descriptors: *Electrical conductance, *Soil chemical properties, Salinity, Saline soils.
Identifiers: Electrical conductivity calculation, Salinity sensors, Saturation extract.

Several methods for calculating the electrical conductivity (EC) of mixed salt solutions have been developed and tested on saturation extract data from 193 soils. Most methods were based on the additivity of values for individual-ion EC in both single-salt and mixed-salt solutions. Calculated and measured EC commonly agreed to within ±0.2 mmhos/cm. Up to 15-40 mmhos/cm., depending upon the method used. A single third-order polynomial for each ion proved satisfactory for predicting the EC of most single salt solutions containing the ion and a counter-ion. Correction factors had to be applied when using these equations for mixed-salt solutions.

70-71:02K-027
SOIL HYDRAULIC CONDUCTIVITY AND BULK VOLUME CHANGES DURING CYCLIC CALCIUM-SODIUM EXCHANGE,
Waldron, L. J., and Constantin, G. K.
California University, Berkeley.
Soil Science, Vol. 110, No. 2, p 81-85, August 1970. 3 fig, 3 tab, 7 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, *Soil management, Soil structure, Groundwater, Hydraulic conductivity.
Identifiers: *Sodium content, *Calcium content, SAR, ESP.

Differences in physico-chemical interaction of $CaCl_2$ and NaCl with six soil types were not suppressed by using concentrated solution of equal ionic strength. In alternating permeation with 0.3 M $NaCl_2$ and 0.9 M NaCl, whenever NaCl replaced $CaCl_2$ the hydraulic conductivity in all soil types decreased. When $CaCl_2$ was reintroduced following NaCl permeation, hydraulic conductivity increased in two of six soils, in each case with decreasing bulk volume. Under the experimental condition, salts apparently exerted their effect on hydraulic conductivity through their influence on aggregate stability. Soil pretreatment with strong NaCl solutions, exerts a large irreversible effect on soil permeability.

70-71:02K-028
THE EFFECT OF ELECTROLYTE COMPOSITION ON HYDRAULIC CONDUCTIVITY OF CERTAIN TEXAS SOILS,
Naghshineh-Pour, B., Kunze, G. W., and Carson, C. D.
Ahwaz Agricultural College, Ahwaz, Iran.
Soil Science, Vol. 110, No. 2, p 124-127, August 1970. 5 fig, 1 tab, 13 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, *Soil management, Soil structure, Groundwater, Hydraulic conductivity.
Identifiers: *Sodium content, *Calcium content, SAR, ESP.

Four well characterized soils,--Houston Black clay, Beaumont clay, Katy fine sandy loam, and the Nacogdoches fine sandy loam--were studied. It is evident that such things as SAR, ESP, electrolyte concentration, clay content, free iron oxides, and clay mineral species are all important factors involved in the hydraulic conductivity of the soils of this study. The most important single factor for the contrasting soils reported is soil mineralogy. The results point out the importance of excluding sodium from the soil system and maintaining a calcium-saturated exchange complex for the soil with high montmorillonite content.

70-71:02K-029
THE CONCENTRATION OF K, CA, AND MG IN THE SATURATION EXTRACT IN RELATION TO EXCHANGEABLE K, CA, AND MG,
Nemeth, K., Mengel, K., and Grimme, H.
Landwirtschaftliche Forschungsanstalt, Buntehof, Hannover.
Soil Science, Vol. 109, No. 3, p 179-185, March 1970. 5 fig, 1 tab, 15 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, Soil management, Calcium, Magnesium, Potassium, Soil structure.
Identifiers: *Saturated extract, Exchangeable.

In 72 soil samples of various texture, the concentration K, Ca, and Mg in the soil solution was studied in relation to other soil properties. The Ca and Mg concentration increased with increasing quantities of exchangeable Ca and Mg regardless of the soil texture. A correlation between the exchangeable K and the K concentration of the soil solution exists only if the soils are classified according to their content of clay and silt. As the percentage K saturation comprises the intensity and the capacity of K supply as well as the buffer capacity, it should characterize the K availability better than exchangeable K alone.

70-71:02K-030
ANION EXCLUSION EFFECTS ON CHLORIDE MOVEMENT IN SOILS,
Thomas, G. W., Swoboda, A. R.
Kentucky University, Lexington; and Texas A & M University, College Station.
Soil Science, Vol. 110, No. 3, p 163-166, September 1970. 5 fig, 1 tab, 9 ref.

Descriptors: *Soil chemistry, *Inorganic compound, *Chlorides, Cation exchange, Anion exchange, Leaching, Groundwater, Soil moisture.
Identifiers: *Anion exclusion, Salt movement.

The effect of anion exclusion on the rate of chloride movement through soils was studied. It was found that in Houston Black Clay the efficiency of chloride movement relative to total water movement was 137 percent at 0.01 N, 119 percent at 0.1 N, 112 percent at 1.0 N concentration. Results of this study suggest that anion exclusion plays an important part in increasing the movement of salt through soils with high cation-exchange capacities.

70-71:02K-031
DISSOLUTION OF DICALCIUM PHOSPHATE IN RELATION TO IRON OXIDE CONTENT OF ACID SOILS,
Sree Ramulu, U. S., Pratt, P. F.
Agricultural College, Coimbatore, Madras, India.
Soil Science, Vol. 109, No. 1, p 35-39, January 1970. 2 fig, 2 tab, 15 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, *Iron oxides, Soil management, Soil science.
Identifiers: *Dissolution, Dicalcium phosphate.

Incubation studies on the persistance or dissolution of dicalcium phosphate dihydrate (DCPD) in 12 soils were conducted over a period of 18 months. The results showed that the time of dissolution of DCPD in soil samples varied inversely with the free iron oxide content of the samples. In samples low in free iron oxides, the points moved toward lower phosphoric acid potential whereas in samples higher in iron oxides, the points corresponding to the solution compositions moved toward the singular point for otacalcium phosphate-strengite.

70-71:02K-032

INFLUENCE OF VARIOUS TREATMENTS ON THE DISSOLUTION OF DICALCIUM PHOSPHATE IN SOILS,

Sree Ramulu, U. S., and Pratt, P. F.
California University, Riverside, Dept of Soils and Plant Nutrition.
Soil Science, Vol. 109, No. 3, p 186-189, March 1970. 2 tab, 16 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, Organic matter, Soil management, Soil Science, Anaerobic conditions.
Identifiers: *Dissolution, Dicalcium phosphate, Preheating.

The effects of preheating wetting and drying and of anaerobic conditions with and without addition of organic matter on the dissolution of Dicalcium phosphate dihydrate (DCPD) in three soils, were studied using phase equilibria. Preheating and/or addition of organic matter to anaerobic samples increased the rate of dissolution of DCPD added to soils whereas wetting and drying treatments increased the rate only to a limited extent. Anaerobic conditions with no organic matter had no measurable effect.

70-71:02K-033

FACTORS AFFECTING THE DETERMINATION OF AVAILABLE SOIL NITROGEN BY CHEMICAL METHODS: I. COMPARISON OF EXTRACTABLE WITH MINERALIZED NITROGEN,

Verstraeten, L. M. J., Vlassak, K., and Livens, J.
Louvain University, Belgium.
Soil Science, Vol. 110, No. 5, p 299-305, November 1970. 4 fig, 2 tab, 12 ref.
(See 70-71:02G-071)

70-71:02K-034

A COMPARISON OF METHODS FOR THE DETERMINATION OF SOIL ORGANIC PHOSPHOROUS,

Williams, J. D. H., Syers, J. K., Walker, T. W., and Rex, R. W.
Lincoln College, Canterbury, New Zealand, Dept of Soil Science; and California University, Riverside, Dept of Geological Sciences.
Soil Science, Vol. 110, No. 1, p 13-17, July 1970. 1 fig, 2 tab, 9 ref.

Descriptors: *Soil chemistry, Organic compounds, Phosphorus.
Identifiers: *Determination methods, New Zealand.

Total organic phosphorous contents of thirteen soil and rock materials were determined using four procedures which involve contrasting analytical approaches. The procedures were the Mehta-Anderson, difference, high temperature ignition, and low temperature ashing. Of the four methods investigated, the Mehta-Anderson procedure was the most satisfactory because it gave the most consistant results over the whole range of phosphorous contents.

70-71:02K-035

MOVEMENT OF SALT AND WATER NEAR CRYSTALLINE SALT IN RELATIVELY DRY SOIL,

Scotter, D. R., Raats, P. A. C.
Wisconsin University, Madison.
Soil Science, Vol. 109, No. 3, p 170-178, March 1970. 9 fig, 17 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, Saline soils, Soil water, Soil management.
Identifiers: *Salt movement, Water movement, Salt dissolution.

Columns of soil with a layer of salt at one end were set up. After a period of time they were sectioned and the water and salt content profiles determined. Columns sampled at different times showed both the profiles to be functions of the distance from the soil-salt interface divided by the square root of the time the experiment was run. A simple physical-mathematical model was developed that described the water movement to the salt and the dissolution of the salt.

70-71:02K-036
COMPONENTS OF pH DEPENDENT CATION EXCHANGE CAPACITY,
Sawhney, B. L., Frink, C. R., and Hill, D. E.
Connecticut Agricultural Experiment Station, New Haven.
Soil Science, Vol. 109, No. 5, p 272-278, May 1970. 2 fig, 4 tab, 18 ref.

Descriptors: *Soil chemistry, *Inorganic compounds, Organic acids, Cation exchange.
Identifiers: *Cation exchange capacity, pH, Natural salt.

The pH dependent cation exchange capacity (CEC) of some acid soils was determined and separated into two different components: weakly dissociated organic acid groups and Al- or Fe-interlayers and coatings. To determine the pH dependent CEC, soils on which natural salt CEC had been determined were treated with NaOAc of pH 8.2, and the CEC redetermined. The difference between the CEC after treatment and the initial CEC gave the pH dependent CEC.

70-71:02K-037
MOVEMENT OF AGRICULTURAL FERTILIZERS AND ORGANIC INSECTICIDES IN SURFACE RUNOFF,
Sievers, D. M., Lentz, G. L., and Beasley, R. P.
Missouri University, Columbia.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 323-325, March 1970. 6 fig, 1 tab, 7 ref.
(See 70-71:05B-049)

70-71:02K-038
THERMODYNAMICS OF SALINE WATER,
Lane, J. E., and Mansfield, W. W.
Division of Applied Chemistry, Fishermen's Bend, Victoria, Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 43-60. 2 fig, 18 ref.
(See 70-71:01B-003)

70-71:02K-039
TRANSPORT OF SALTS IN UNSATURATED AND SATURATED SOILS,
Peck, A. J.
Division of Soils, Wembley, Western Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971. Canberra, Australia, p 109-123. 1 fig, 67 ref.
(See 70-71:02F-061)

70-71:02K-040
SALINITY AND THE WHOLE ANIMAL,
Macfarlane, W. V.
Adelaide University, South Australia, Waite Agricultural Research Institute.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 161-178. 2 fig, 4 tab, 62 ref.

Descriptors: *Water chemistry, *Salinity, *Biology, Animal growth, Metabolism, Animal pathology, Environmental effects, Animal Metabolism, Biochemistry, Moisture stress.
Identifiers: Animal cells.

Land mammals have neuroendocrine controls and cellular pumping mechanisms to maintain electrolyte concentrations. In the arid hot areas the salinity of water reaches four or more times that of body fluids. Either such water is not consumed or kidneys are developed to excrete the excess salts. Salt tolerances of different animals are listed. There are species limits to the salinity of water that can be tolerated without strain. Some species have high intrinsic tolerances to salinity but most animals require weeks of gradual exposure, before an equilibrium is reached. The degree to which growth, fertility, and efficiency are reduced by saline waters is determined by species or breed of animal; and the effects are modulated by food, air temperature, age and lactation.

70-71:02K-041
SALINITY AND ANIMAL CELLS,
Gage, P. W.
South Wales University, Kensington, Australia, School of Physiology
and Pharmacology.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 179-191. 4 fig, 10 ref.

Descriptors: *Water chemistry, *Salinity, *Biology, Animal growth, Metabolism, Animal pathology, Environmental effects, Animal metabolism, Biochemistry, Moisture stress, Sodium.
Identifiers: Animal cells.

Biological cells exist in a saline environment which differs in ionic composition from the intracellular solution. Potassium is more concentrated inside, whereas sodium is more concentrated outside, cells. In the resting state, cell membranes are more permeable to potassium than to sodium ions and this results in an electrical potential across the membrane, negative inside. The transmission of electrical signals, communication between cells, and the conversion of environmental energy to electrical signals, all depend on an inflow of sodium ions into cells as a result of an increase in the sodium permeability of the cell membrane. The intracellular concentrations of sodium and potassium ions are regulated by metabolically "fuelled" ionic pumps. Because membrane potentials are essentially ionic diffusion potentials, the concentration gradients of sodium and potassium ions are of fundamental importance in the generation of electrical signals which are hence very sensitive to the concentration of these ions in the extracellular saline.

70-71:02K-042
SALINITY AND THE WHOLE PLANT,
Robinson, J. B.
University of Adelaide, South Australia, Dept of Agriculture.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 193-206. 1 fig, 3 tab, 42 ref.

Descriptors: *Water chemistry, *Salinity, *Biology, Plant growth, Plant pathology, Plant physiology, Environmental effects, Biochemistry, Moisture stress.
Identifiers: Plant cells.

The deficiencies in present knowledge concerning the behavior of ionic species within the plant are discussed, with particular reference to the leaf; and a possible experimental approach to these problems is developed. Briefly, a distinction must be made between ions entering plant tissue and subsequent partition of ions between extracellular and cellular compartments. With techniques at present available the dynamic state of the extracellular compartment with respect to any particular ion can be determined. Using tissue slices, and duplicating the native state of the leaf cell, information on the ionic and water relations of the leaf cell could be obtained. Extrapolation of such data to the native state may enable distinction to be drawn between the 'osmotic' and 'specific ion toxicity' theories of salt damage.

70-71:02K-043
SALINITY AND PLANT CELLS,

Campbell, L. C., and Pitman, M. G.
Sydney University, New South Wales, Australia, School of Biological Sciences.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 207-224. 6 fig, 3 tab, 45 ref.

Descriptors: *Water chemistry, *Salinity, *Biology, Plant growth, Plant pathology, Plant physiology, Environmental effects, Biochemistry, Moisture stress.
Identifiers: Plant cells.

This paper discusses regulation of ionic content by plant cells and possible ways salinity may disrupt cell function and development. Selective uptake of K relative to Na has some importance but in general, plants seem less dependent on ionic balance than do animal cells. The effect of salinity and osmotic pressure on the activity of mitochondria and chloroplasts is discussed in relation to electron transport processes. It is suggested that some of the effects of salinity on cell activity can be explained in terms of membrane structure.

70-71:02K-044
IMPLICATIONS OF THE PRESENT STATE OF SCIENTIFIC KNOWLEDGE FOR TECHNICAL MANAGEMENT,
England, H. N.
Water Conservation and Irrigation Commission, Sydney, New South Wales, Australia.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 257-273. 9 ref.

Descriptors: *Salinity, *Management, *Technology, Water utilization, Water quality, Hydrology, Soil chemistry, Water chemistry.

Salinity, from a management viewpoint, is discussed under the headings of hydrology, use of saline waters and control of soil and stream salinity, with incidental reference to other Symposium papers. The main theme is the conflict between control of soil salinity under irrigation and downstream river salinity, with the conclusion that the high quality of Australian surface waters should be preserved at the expense of minor loss of land to salt in the semi-arid floodplain environment, where most irrigation development and potential are situated.

70-71:02K-045
SALINITY AND WATER USE: FUTURE RESEARCH DIRECTIONS,
Martin, A. E.
Commonwealth Scientific and Industrial Research Organization, Saint Lucia, Queensland, Australia, Soils Division, Cunningham Laboratory.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 275-284. 2 ref.

Descriptors: *Salinity, *Water utilization, *Management, *Technology, Research priorities, Water quality, Water chemistry.
Identifiers: *Research needs.

Future research directions in salinity at the molecular level are already predetermined, and will probably concern the details of ion pumping in cell membranes, the development of new antibiotics, the emergence of salt-tolerant plants and the like. The real problems lie in the catchments and will need the application of terrestrial field research for their solution. A brief analysis of the status of field research is presented and some reasons for its unpopularity are suggested. It is concluded that new research should concentrate on the location of saline soils, sediments and groundwaters more intensively than hitherto, on the origin of terrestrial salt, on the factors responsible for secondary salinity in soils, water supplies and irrigation areas, and on their reclamation. There is acute need for research on the social consequences of a contracting population in irrigation enterprises that suffer partial failure.

SECTION XII

WATER SUPPLY AUGMENTATION AND CONSERVATION

SALINE WATER CONVERSION (Group 03A)

70-71:03A-001
DESALTING TECHNOLOGY IN POLLUTION-CONTROL PROBLEMS,
Young, K. G.
Reading and Bates Offshore Drilling Company, Tulsa, Oklahoma.
Journal of the American Water Works Association, Vol. 63, No. 1, p 21-24,
January 1971. 5 fig, 10 ref.

Descriptors: *Waste water treatment, *Semipermeable membranes, *Desalination processes, Flash distillation, Vapor compression distillation, Reverse osmosis, Electrodialysis, Scaling, Economic feasibility, Desalination, Osmosis.
Identifiers: Multi-stage flash distillation, Multiple effect distillation.

As natural sources of fresh water are depleted and as the volume of liquid wastes and their disposal problems increase, the economic and resource conservation benefits related to the complete recovery of pure water from saline or contaminated sources become increasingly favorable. Three proposed procedures to desolve pollution problems are outlined with emphasis placed on economic considerations. These same economic standards are applied to desalting methods which in recent years have improved their feasibility, and thus their utility. Several desalting methods currently in commercial use or being developed are briefly reviewed. Four principle methods are: distillation, deionization by membranes, salt separation by freezing, and chemical deionization; however, since the latter two methods have definite performance limitations in pollution control application, broader descriptions of distillation and deionization by membranes are presented. The Multi-stage flash, Multiple effect, and Vapor compression distillation processes, all of which employ some type of regenerative thermal cycle and reverse osmosis and electrodialysis (membrane methods) are dealt with in greater detail. Desalting techniques described seem certain to play an ever-increasing part in providing practical and economical solutions to pollution-control problems involving waste water.

70-71:03A-002
CONQUEST OF WASTES SHOW PRODUCTIVITY,
Hodge, Carl O., and Kassander, A. Richard, Jr.
University of Arizona, Tucson, Environmental Research Laboratory.
Reclamation Era, Vol. 57, No. 1, p 14-16, February 1971. 3 fig.
(See 70-71:02D-020)

70-71:03A-003
THERMODYNAMICS OF SALINE WATER,
Lane, J. E., and Mansfield, W. W.
Commonwealth Scientific and Industrial Research Organization, Fishermen's Bend, Victoria, Australia, Division of Applied Chemistry.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 43-60. 2 fig, 18 ref.
(See 70-71:01B-003)

SECTION XIII

WATER SUPPLY AUGMENTATION AND CONSERVATION

WATER YIELD IMPROVEMENT (Group 03B)

70-71:03B-001
GROUNDWATER PROBLEMS OF THE INTERACTION OF SALINE AND FRESH WATER,
Wooding, R. A.
Commonwealth Scientific and Industrial Research Organization, Canberra,
Australia, Division of Environmental Mechanics.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4,
1971, Canberra, Australia, p 125-139. 55 ref.
(See 70-71:01B-004)

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SECTION XIV

WATER SUPPLY AUGMENTATION AND CONSERVATION

USE OF WATER OF IMPAIRED QUALITY (Group 03C)

70-71:03C-001
WATER RELATIONS AND GROWTH OF COTTON AS INFLUENCED BY SALINITY AND RELATIVE HUMIDITY,
Hoffman, G. J., Rawlins, S. L., Garber, M. J. and Cullen, E. M.
Agricultural Research Service, Riverside, California, Soil and Water Conservation Research Division; and California University, Riverside, Department of Statistics.
Agronomy Journal, Vol. 63, No. 6, p 822-826, November-December 1971. 4 fig, 4 tab, 17 ref.

Descriptors: *Cotton, *Salt tolerance, *Leaves, *Transpiration, *Plant growth, Plant root systems, Pollen, Laboratory tests, Temperature, Humidity, Crop production, Soil-water-plant relationships, Osmotic pressure, Water balance.
Identifiers: *Plant water potential, *Relative humidity.

Previous research has indicated interactive effects between soil salinity and relative humidity (RH) in bean plant growth. This interaction was studied in growing cotton plants in 4 sunlit climate chambers. The chambers were controlled at 25, 40, 65 and 90% RH. Plant root media were maintained at osmotic potentials of -0,4, -5, -10, and -15 bars in the climate chambers. Shoot growth increased by 40% in the 90% RH atmosphere and was unaffected at other RHs. High RHs caused at least a doubling of the root/shoot ratio. Seed cotton yields were at field yield levels only in the 40 and 65% climates because the flowers did not undergo another dehiscence at the extreme RHs. Transpiration per unit leaf area ratio increased about 80% at all salinity levels as the RH decreased from 90%. With humidity a constant, it decreased slightly with salinity increase. Plant age was also a factor in transpiration levels, causing decreases with increasing age. Since the yields of dry matter as a function of salinity did not vary with RH, it appeared that there was no interaction between salinity and RH. This was reinforced by the same results with leaf area as a function of salinity at different reactive humidities.

70-71:03C-002
DRIP IRRIGATION - A METHOD USED UNDER ARID AND DESERT CONDITIONS OF HIGH WATER AND SOIL SALINITY,
Goldberg, D., and Shmueli, M.
American Society of Agricultural Engineers Transactions, Vol. 13, No. 1, p 38-41, January-February 1970. 10 fig, 3 tab, no ref.

Descriptors: *Irrigation effects, *Irrigation design, *Arid lands, *Saline soils, *Saline water, Salinity, Deserts, Soil texture, Crop production, Irrigation systems, Nozzles, Irrigation water, Irrigation engineering, Irrigation efficiency, Furrow irrigation, Fertilizers, Equipment.
Identifiers: *Drip irrigation, *Israel.

Drip irrigation has many advantages over other forms of irrigation when used in arid regions characterized by saline soil, saline irrigation water, and high evapotranspiration rates. It shortens growing seasons, produces earlier crops, increases crop yield, and makes it possible to grow crops which would normally be salt-damaged. A summary of experimental results is presented which support these conclusions. Also a technical description of the system is included and certain soil problems as they relate to the drip irrigation method are discussed.

70-71:03C-003
INCREASING THE AGRICULTURAL USE OF SALINE WATER BY MEANS OF TRICKLE IRRIGATION,

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Goldberg, D., Gornat, B., Shmueli, M., Ben-Asher, I., and Rinot, M.
Hebrew University, Rehovoth (Israel), Dept of Irrigation.
Water Resources Bulletin, Vol. 7, No. 4, p 802-809, August 1971. 5 fig, 6 tab, 8 ref.

Descriptors: *Irrigation systems, *Irrigation efficiency, *Crop response, *Saline water, Soil-water-plant relationships, Water quality, Arid lands.
Identifiers: *Trickle irrigation.

A study was conducted in two arid zones in Israel to determine the effect of saline water applied to various crops growing in coarse-textured soil, using trickle irrigation. The test crops responded favorably in terms of plant development and yield. The method provides the possibility of raising the permissible salinity level of irrigation water and thus to increase the water reserves suitable for agricultural use in the world. The experiments were conducted in two arid regions with saline water sources. The first is the Arava near the Gulf of Aquaba, and the second is the El-Arish district in the northern part of the Sinai desert. In general, the Arava soils are finer textured and more saline than those at El-Arish. The water contains more sulphates, and the climate is very hot and dry. In the El-Arish district, the soil is very sandy, and its salinity is low. However, the water is highly saline, and the chlorine content is also high. The yield from trickling in the Arava was double that obtained by sprinkling, and at El-Arish it was 70% greater. For tomatoes in the Arava, the yield by trickling was 66% greater than that achieved by sprinkling, and at El-Arish it was 161% greater.

70-71:03C-004
DESALTING SALINE WATER FOR IRRIGATION--A CASE STUDY--COACHELLA AREA,
Krous, E. S.
Bureau of Reclamation, Boulder City, Nevada.
Paper 6th American Water Resources Conferences Conference, Las Vegas, Nevada, October, 1970. 19 p, 8 fig, 4 tab, 14 ref.

Descriptors: *Demineralization, *Saline water, *Agriculture, Salinity, *Irrigation water, Membrane processes, Desalination processes, Water costs, Distillation, Benefit-cost ratios, Investment, Crop production, Bibliographies, Brine disposal, Consumptive use (Water), Multistage flash distillation, Operating costs, Water sources, Costs, *Desalination.
Identifiers: *Saline agriculture, Coachella Valley (California).

A study was performed to evaluate potential applications of desalted saline water for agriculture using 2 distillation and 2 membrane processes. The investigation determined costs and benefits associated with desalting saline water at concentrations of 1500, 900, 400, 200 and 50 ppm. Benefits from desalting are generated by shifts to more profitable crops, reduced costs for drainage, and reduced fertilizer and labor requirements with better quality water. Costs are based on project features such as desalting plants, raw water diversion facilities, storage reservoirs, conveyance and distribution systems, brine disposal, blending facilities, and gypsum addition systems. Hydrologic studies determined crop irrigation requirements, water demand schedules, desalted water storage requirements, brine disposal requirements, and size of facilities required. Reconnaissance design layouts were made for producing desalting water using a combination of 14 schemes. Benefit-cost ratios range from 0.4 to 1.0 for 1500 ppm irrigation water to 0.8 to 1.0 for 50 and 200 ppm water. Investment costs per acre are high, ranging from $12,900 to $20,900. Irrigation benefits are based on the increase in production from a desert condition with no water supply to the irrigation conditions studied.

70-71:03C-005
SUPPLEMENTAL IRRIGATION WITH STREAM WATER CONTAMINATED BY ACID MINE DRAINAGE,
Terkeltoub, Richard W.

Agricultural Research Service, University Park, Pennsylvania, Northeast Watershed Research Center.
Water Resources Research, Vol. 7, No. 3, p 704-708, June 1971. 5 p, 2 fig, 1 tab, 3 ref.

Descriptors: *Acid mine water, *Irrigation water, *Pennsylvania, Water pollution control, Iron, Hydrogen ion concentration, Water utilization, Flooding, Water chemistry, Soil-water-plant relationships, Water quality, Sampling, Impaired water quality.

Many streams in the Appalachian coal producing region, which could furnish supplemental irrigation water, are polluted with acid mine drainage. They consequently contain much greater trace concentrations and have lower pH than do nearby streams that carry only agricultural drainage. Nevertheless, supplemental irrigation of barley plants grown in a greenhouse with acid mine water was as beneficial to plant growth as supplemental irrigation with deionized water. The capacity of the soil to buffer pH and adsorb trace metals apparently counteracts the properties of acid mine water, which are detrimental to plant growth. Furthermore, the agricultural quality of a field often flooded with acid mine water has been maintained by adding lime to offset the reduced pH. Thus under certain soil conditions and management practices, acid mine water can be used for supplemental irrigation.

70-71:03C-006
SALINE ARTESIAN WATER AS A SUPPLEMENT,
Meyer, Frederick W.
Geological Survey, Miami, Florida.
Journal of the American Water Works Association, Vol. 63, No. 2, p 65-71, February 1971. 7 p, 10 fig, 9 ref.

Descriptors: *Water resources development, *National parks, *Florida, *Saline water, *Artesian wells, Confined water, Water quality, Salinity, Water chemistry, Hydrogeology, Water sources, Groundwater movement, Aquifer characteristics.
Identifiers: *Everglades National Park (Florida).

Large quantities of moderately saline water (less than 5,000 mg/liter dissolved solids) can be obtained from artesian water-bearing zones in the Avon Park Limestone of Eocene age--top of which occurs at a depth of about 1,200 ft in southern Florida. Small quantities of less saline water can be obtained from artesian water-bearing zones in the Hawthorn, Tampa, and Suwannee Formations between 300 and 1,100 ft in depth. Artesian water could be used for small desalting plants in the Florida Keys and the Coastal Lowlands area at considerable savings over using sea water. The use of raw artesian water from below 1,300 ft for dry-weather biologic survival ponds in the Everglades, such as in the Everglades National Park, is infeasible because the salinity is too high for some species of plants and animals. Generally, piezometric levels, salinities, and flows increase with depth in southern Florida.

70-71:03C-007
INFLUENCE OF SOIL SALINITY ON PRODUCTION OF DRY MATTER AND UPTAKE AND DISTRIBUTION OF NUTRIENTS IN BARLEY AND CORN: I. BARLEY (HORDEUM VULGARE L.),
Hassan, N. A. K., Drew, J. V., Knudsen, D., and Olson, R. A.
Agricultural Experiment Station, Abu-Ghraib, Iraq, Soils Department.
Agronomy Journal, Vol. 62, No. 1, p 43-45, 1970. 2 tab, 1 fig, 10 ref.
(See 70-71:05C-007)

70-71:03C-008
GROWTH AND WATER POTENTIAL OF ROOT CROPS AS INFLUENCED BY SALINITY AND RELATIVE HUMIDITY,
Hoffman, G. J., and Rawlins, S. L.

Agricultural Research Service, Riverside, California, U.S. Department of Agriculture.
Agronomy Journal, Vol. 63, No. 6, p 877-880, 1971. 4 tab, 4 fig, 12 ref.
(See 70-71:02G-056)

70-71:03C-009
STARTING WITH TRICKLE IRRIGATION,
DeRemer, E. D.
Business Dynamics Corporation, Phoenix, Arizona.
Reclamation Era, Vol. 56, No. 4, p 15-17, November 1970.

Descriptors: *Irrigation systems, *Application methods, *Water conservation, Sprinkler irrigation, Irrigation engineering, Water pollution, Groundwater, Crop production, Lemons, Tomatoes, Melons, Sweet corn.
Identifiers: *Trickle irrigation, *Irrigation research, Peppers, Cucumbers.

Trickle irrigation has been receiving much publicity and attention throughout the world. This article shows that several workers, independent of each other, are reporting phenomenol water savings and sizable yield increases. Studies in Israel show yield increases of 50 to 100 percent with trickle irrigation as compared to sprinkler or furrow irrigation for tomatoes, cucumbers, melons, peppers, and sweet corn. Trickle irrigation was used on a 10 acre plot of lemons near Yuma, Arizona, with the following results. Water use was 1/9th, irrigation labor cost was 1/16th. Cultivation was reduced by 60 percent; fertilizer use was 20 percent, and yield was more than double. Another benefit of trickle irrigation is that poorer quality water can be used with no apparent damage to the area.

70-71:03C-010
TRICKLE IRRIGATION. . . A MORE EFFICIENT MEANS OF WATER MANAGEMENT,
Lyons, C. G., Jr.
Texas Agricultural Extension Service, Welasco, Texas.
Texas Agricultural Progress, Vol. 18, No. 1, p 3-4, Winter, 1972. 5 fig.

Descriptors: *Irrigation systems, *Application methods, *Water conservation, Irrigation engineering, Water pollution, Groundwater, Crop production.
Identifiers: *Trickle irrigation, *Drip irrigation, *Daily flow, Irrigation research.

The sudden increase in the use of trickle irrigation is attributed to the availability of low cost plastic pipe and the shortage of water in some areas. Trickle irrigation is the application of water, on a regular basis, directly to the plants' root zone. A trickle system consists of a water source, pump, filter, time clock, pressure regulator, mainline, laterals, and emitters. Costs for the system vary from $150 to $500 per acre. Advantages of the method include water and labor savings, increased yield, and ability to use lower quality water. Disadvantages include system malfunction, salt accumulation, disease factors, and cost.

70-71:03C-011
CALIFORNIA DRIP-IRRIGATION TESTS MAY PROVE METHOD SIGNIFICANT,
Irrigation Journal.
Irrigation Journal, Vol. 21, No. 2, p 12-13, March-April 1971.

Descriptors: *Irrigation systems, *Application methods, Water Conservation, Sprinkler irrigation, Irrigation Engineering, Water pollution, Ground water, Crop production.
Identifiers: *Drip-irrigation, *Irrigation research, Avocados.

The drip-irrigation method of watering plants is now being tested on a 5-acre plot near Bonsall, California. The experiment is designed to evaluate the differences between drip-irrigation and the standard sprinkler type. The crop consists of avocado trees. Watering is for 4 hours daily with a flow rate of 12-15 gallons weekley. There are 3 drippers to a tree, one at the trunk and 2 at 2 feet from the trunk. The main objectives are to save water, reduce labor and "Americanize" the system.

70-71:03C-012
NEW FINDINGS ON THE USE OF TRICKLE IRRIGATION SYSTEMS IN THE UNITED STATES, AUSTRALIA & ISRAEL,
DeRemer, E. D.
Business Dynamics Corporation.
World Irrigation, Vol. 20, No. 6, p 14-16, December 1970. 4 fig, 1 tab.

Descriptors: *Irrigation systems, *Application methods, *Water conservation, Sprinkler irrigation, Irrigation engineering, Water pollution, Groundwater, Crop production, Lemons, Tomatoes, Melons, Sweet corn.
Identifiers: *Trickle irrigation, *Irrigation research, Peppers, Cucumbers.

Trickle irrigation has been receiving much publicity and attention throughout the world. This article shows that several workers, independent of each other, are reporting phenomenol water savings and sizable yield increases. Studies in Israel show increases of 50 to 100 percent with Trickle Irrigation as compared to sprinkler or furrow irrigation for tomatoes, cucumbers, melons, peppers, and sweet corn. Trickle Irrigation was used on a 10-acre plot of lemons near Yuma, Arizona, with the following results. Water use was 1/19th irrigation labor cost was 1/16th. Cultivation was reduced by 60 percent; fertilizer use was 20 percent, and yield was more than double. Another benefit of Trickle Irrigation is that poorer quality water can be used with no apparent damage to the area.

70-71:03C-013
EFFECTS OF VARIOUS SALINITY REGIMES ON GROWTH, LEAF EXPANSION AND TRANSPIRATION OF BEAN PLANTS,
Meiri, A., and Mayber, A. P.
Volcani Institute of Agricultural Research, Israel.
Soil Science, Vol. 109, No. 1, p 26-34, January 1970. 5 fig, 5 tab, 20 ref.
(See 70-71:02I-019)

70-71:03C-014
SALINITY AND ANIMAL CELLS,
Gage, P. W.
South Wales University, Kensington, Australia, School of Physiology and Pharmacology.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 179-191. 4 fig, 10 ref.
(See 70-71:02K-041)

70-71:03C-015
SALINITY AND THE WHOLE PLANT,
Robinson, J. B.
University of Adelaide, South Australia, Dept of Agriculture.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 193-206. 1 fig, 3 tab, 42 ref.
(See 70-71:02K-042)

70-71:03C-016
SALINITY AND PLANT CELLS,
Campbell, L. C., and Pitman, M. G.
Sydney University, New South Wales, Australia, School of Biological Sciences.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 207-224. 6 fig, 3 tab, 45 ref.
(See 70-71:02K-043)

70-71:03C-017
ECONOMIC AND SOCIAL ASPECTS OF SALINE WATER USE AND MANAGEMENT,
Callinan, B. J., and Webster, R. G.
Gutteridge, Haskins, and Davey; Melbourne, Victoria, Australia.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 227-242. 4 fig, 3 tab, 5 ref.

Descriptors: *Salinity, *Management, *Economics, Economic impact, Social aspects, Social impact, Social participation, Water pollution affects.

Salinity problems resulting from high salinities in streams and in shallow watertables arise frequently from the clearing of forests and from irrigation. The evaluation of the consequences of salinity problems must commence with clear knowledge and understanding of the economic and social bases upon which the region functions. The evaluations are difficult due to: (i) The absence of bases upon which to commence. (ii) Losses being frequently caused more to those downstream than to those whose lands create the problems. (iii) The wide areas of adaptabilities of processes to conditions and salinities. Salinity control measures are essentially long-term and their economic evaluation is best made with discount rates which are reduced for long-term costs and benefits. The social consequences, whilst difficult to evaluate, must be given due weight in the light of deteriorating conditions in the metropolises. The effects of high salinities can be lessened in areas already affected, and avoided in areas about to be developed, by the application of lessons now available to proposed investigations, planning and control. Planning legislation can be used to exercise essential controls.

70-71:03C-018
ADMINISTRATIVE AND LEGAL ASPECTS OF SALINE WATER USE AND MANAGEMENT,
Clark, S. D., and Meacham, I.
Melbourne University, Victoria, Australia.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 243-254.

Descriptors: *Salinity, *Management, *Legal aspects, Legislation, Water utilization, Water law, Water policy, Water pollution, Water quality.

The Senate Select Committee on Water Pollution reporting in 1970, pointed to the lack of effective control, at that time, over the dangers of water pollution throughout Australia. One possible form of Administrative structure at the State level, to combat these dangers, is exemplified by the central administration set up by the Environment Protection Act, passed by the Victorian Parliament late in 1970, to cover all aspects of environmental pollution. At the inter-State and Commonwealth-State levels there are special legal and administrative problems to be faced. Control of salinity on the River Murray will depend on a practicable solution to these problems being found. A satisfactory administrative structure to operate at these levels could be built on the experience and advice of central pollution-control administrations, established within the separate States.

70-71:03C-019
IMPLICATIONS OF THE PRESENT STATE OF SCIENTIFIC KNOWLEDGE FOR TECHNICAL MANAGEMENT,
England, H. N.

Water Conservation and Irrigation Commission, Sydney, New South Wales, Australia.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 257-273. 9 ref.
(See 70-71:02K-044)

70-71:03C-020
SALINITY AND WATER USE: FUTURE RESEARCH DIRECTIONS,
Martin, A. E.
Commonwealth Scientific and Industrial Research Organization, Saint Lucia, Queensland, Australia, Soils Division, Cunningham Laboratory.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 275-284. 2 ref.
(See 70-71:02K-045)

SECTION XV

WATER SUPPLY AUGMENTATION AND CONSERVATION

CONSERVATION IN AGRICULTURE (Group 03F)

70-71:03F-001
SOME EFFECTS OF SOIL MOISTURE STRESS ON THE GROWTH OF WHEAT (TRITICUM AESTIVUM L. EM THELL.),
Day, A. D., and Intalap, Suhbawatr.
Arizona Agricultural Experiment Station, Tucson.
Agronomy Journal, Vol. 62, No. 1, p 27-29, January-February 1970. 3 tab, 14 ref.

Descriptors: *Wheat, *Soil moisture, *Moisture stress, *Plant growth, *Crop response, Crop production, Seeds, Grains (Crops), Growth stages, Flowering, Arid lands, Arizona, Water requirements, Water utilization, Soil water, Irrigation, Irrigation effects, Environmental effects, Cereal crops, Particle size, Soil-water-plant relationships.
Identifiers: *Spring wheat, Jointing, Dough, Grain weight.

The effects of soil-moisture stress on growth and grain yield of spring wheat were studied in Arizona in 1966 and 1967. The wheat was planted in December and stressed at three different stages of development: jointing, flowering, and dough. The critical period for moisture was the jointing stage. Moisture stress at jointing resulted in earlier maturity, shorter plants, increased lodging, fewer seeds per head, fewer heads per unit area, lower grain volume-weight, and lower grain yield. Stress at any growth stage hastened maturity and decreased grain yield. However, when wheat was stressed at jointing grain yield reduction was due to fewer seeds per head and fewer heads per unit area, while lower yields in wheat stressed at flowering or dough resulted from lighter seed-weight. In order to achieve maximum grain yield, optimum irrigation must be provided throughout the entire growing season, not just during the critical jointing stage.

70-71:03F-002
EFFECT OF PLANT DENSITY AND GROWTH DURATION ON GRAIN SORGHUM YIELD UNDER LIMITED WATER SUPPLY,
Blum, A.
National and University Institute of Agriculture, Rehovoth (Israel). Volcani Institute of Agriculture Research.
Agronomy Journal, Vol. 62, No. 3, p 333-336, May-June 1970. 5 fig, 1 tab, 13 ref.

Descriptors: *Sorghum, *Crop production, *Limiting factors, *Density, *Water supply, Environmental effects, Arid lands, Semiarid climates, Soil moisture, Soil water, Moisture stress, Vegetation effects, Plant populations, Plant growth, Growth stages, Mature growth stage, Growth rates, Time, Competition, Grains (Crops).
Identifiers: *Israel, *Water-use efficiency, *Plant density, Hybrid sorghum.

Hybrid grain sorghum grown entirely by stored soil moisture was studied in two experiments in Israel. In one experiment, sorghum hybrids were planted in 12 densities ranging from 2.9 to 27.9 plants per square meter and grown with 302 mm available soil water. Grain yield of an early maturing hybrid was highest under high plant density and yield of the late maturing hybrid was highest under low density. These relationships were also consistent regarding yield per plant, number of heads per plant, and number of grains per panicle. The highest yield for the entire experiment was from the earliest maturing hybrid planted at the densest population. Grain yield components were suppressed by increased competition and the early maturing hybrid at highest density attained its superiority by maintaining larger grain size in spite of increased interplant competition for water. A second experiment found that water use increased with increasing plant density. An early maturing hybrid used less water at all stages of growth than a later maturing hybrid.

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70-71:03F-003
EFFECT OF GYPSUM AND DROUGHT STRESSES ON MAIZE (ZEA MAYS L.): II. CONSUMPTIVE USE OF WATER,
Downey, Lloyd A.
Dept of Agriculture of New South Wales, Leeton (Australia). Agricultural Research Station.
Agronomy Journal, Vol. 63, No. 4, p 597-600, 1971. 5 fig, 4 tab, 13 ref.

Descriptors: *Moisture stress, *Gypsum, *Consumptive use (water), Corn, Drought.
Identifiers: Consumptive, Evapo, Maize-M, Stress, Transpiration, Turgidity, Water Zea-Mays-M.

The effect of 3 defined periods of drought stress on the consumptive use of water by field grown maize (Zea mays L.) was measured using a complete water balance approach. Water status within the crop was defined by noon measurements of relative turgidity (RT). The treatments were set out in a randomized block design with a further comparison between the untreated (sodic) soil and the same soil treated with gypsum at 22.4 m tons ha-1. The components of the water balance--soil stored moisture, rain, and applied irrigation--were measured directly, and deep drainage was calculated from chloride redistribution. The no-stress treatment (RT at noon maintained > 90%) used 59 cm in evapotranspiration during the growing period. Drought stress (RT at noon < 90%) for a period of 20 days during male meiosis (early stress) reduced this total evapotranspiration to 44 cm, while drought stress during grain filling (late stress) reduced it to 51 cm. The application of gypsum had no significant effect on water use nor on water entry at irrigation. Application efficiency (total evapotranspiration/total applied water) was 86%, 79%, and 85% on the no-stress, early-stress, and late-stress treatments respectively. The balance (15 to 20%) of applied water was lost as deep drainage, indicating that results on more permeable soils would be inaccurate if this component were ignored. Maximum water use of 0.9 cm day-1 (or 0.8 of class 'A' pan) occurred during anthesis. This period was delayed 10 days by early stress. Water use efficiency was highest for the early stress-87 Kg dry grain/cm water/ha and lowest for the late stress-26 kg.

70-71:03F-004
PROFILE MODIFICATION AND ROOT YIELD, DISTRIBUTION, AND ACTIVITY,
Eck, H. V., and Davis, R. G.
Southwestern Great Plains Research Center, Bushland, Texas.
Agronomy Journal, Vol. 63, No. 6, p 934-937, November-December 1971. 2 fig, 2 tab, 18 ref.

Descriptors: *Plant root systems, *Crop response, *Productivity, *Root development, *Root distribution, Soil moisture, Soil profiles, Sodium, Carbonates, Strontium radioisotopes, Agronomic crops.

Drastically altering a soil profile with a root-impeding layer may alter root yield and distribution with depth. The effects of deep plowing or profile modification on root distribution have been little studied. Characterization of root systems and root penetration measurements are difficult. In this study, deep plowing and Na carbonate application for reducing radiostrontium uptake were compared by sampling from 4 crops with the objective of determining treatment effects on root yield and distribution and of examining relationships between root yields and root activity as indicated by the top-root ratios and Sr-35 uptake. Deep plowing decreased root yields of sudangrass, sugar beets and soybeans but had little effect on cabbage roots. Yields decreased with depth on soil rototilled to 20 cm but tended to be evenly distributed throughout the 90 cm profile when 22,400 kg/ha of sodium carbonate was applied at a 90 cm plow depth. Root activity was definitely enhanced by profile modification. Sr-35 activity indicated that roots in the 70-90 cm root zone were as active as roots in the 10-20 cm zone.

70-71:03F-005
EFFECT OF SEEDBED CONFIGURATION AND COTTON BUR MULCH ON LINT COTTON YIELD, SOIL WATER, AND WATER USE,
Koshi, P. T., and Fryrear, D. W.
Agricultural Research Service, Soil and Water Conservation Research Division, Big Spring, Texas.
Agronomy Journal, Vol. 63, No. 6, p. 817-821, November-December 1971. 4 fig, 7 tab, 11 ref.

Descriptors: *Cotton, *Dry farming, *Mulching, *Water conservation, *Cultivation, Furrows, Semiarid climates, Texas, Great Plains, Rainfall, Water storage, Soil moisture, On-site investigations.
Identifiers: *Seedbed configurations.

Dryland agriculture in the Southern High Plains depends on the most efficient use of available water. Droughts are frequent and the low humidity, high temperatures and wind velocity result in high evapotranspiration. Approximately 30% of the harvested cotton accumulates at the cotton gin as cotton burs or gin trash and may be returned to the cotton fields for mulch. This study was designed to determine the influences of 3 seedbed configurations (flat, ridge and furrow) and 3 mulch rates (5.6, 11.2 and 22.4 tons/ha) on soil water accretion and depletion under cotton on a moderately sandy soil in a semiarid climate. Preseason soil water storage, as measured by neutron scattering, was directly proportional to amount of bur mulch, as were precipitation storage efficiencies. Furrow plots had the highest accretion, and ridge plots, generally, the lowest. All results held true for 2 crop years, 1968 and 1969. Yields were highest and similar for the 11.2 and 22.4 tons/ha plots, but were also significantly greater for the 5.6 ton/ha plots as compared to the plots with no mulch.

70-71:03F-006
SOIL WATER POTENTIAL AND WATER CONTENT PROFILES WITH WHEAT UNDER LOW SPRING AND SUMMER RAINFALL,
Papendick, R. I., Cochran, V. L., and Woody, W. M.
Agricultural Research Service, Pullman, Washington, Soil and Water Conservation Research Division.
Agronomy Journal, Vol. 63, No. 5, p 731-734, 1971. 4 fig, 11 ref.

Descriptors: *Soil water, *Moisture tension, *Rainfall, Moisture availability, Wheat.
Identifiers: Northwest, Pacific, Penetration, Potential, Profiles, Psychrometry, Root, Soil, Spring, Summer, Thermocouple, Triticum-Aestivum-M, Wheat-M.

Soil water potentials and water contents in the wheat (Triticum aestivum L.) root zone of several soils were measured (by thermocouple psychrometry) late in the growing season under Pacific Northwest, USA conditions of low spring and summer rainfall. All profiles exhibited low potentials in the surface 1 to 1.5 m of soil, followed by a region of steep potential gradient over a depth increment of 30 cm or more. Below this region the energy values were relatively constant with depth. In the dry zone the soil water potential in some cases reached -45 bars at the 60- or 90-cm depth, and in one case, -40 bars at the 150-cm depth. With coarser-textured soils the potential gradient across the moist to dry zone was steeper as compared with a finer-textured soil. Depth of root penetration appeared to coincide with the base of the steep water-potential gradient. Plant wilting was absent or not pronounced when potentials below the steep gradient zone were -2 bars or higher; permanent or severe wilting occurred when the potential was -10 to -8 bars. Soil water potentials in the surface 1.5 m of soil were 8 to 10 bars lower with 110 and 220 kg N/ha applications on wheat than with no N. In most cases the water content profiles of the root zone bore little resemblance to the corresponding potential profiles. These results indicate that in the field the lower limit of water extraction by wheat may reach -40 bars or lower. However, the mobility of water in the root zone or adjacent layers underlying the root zone of the field soil is probably more important to the concept of water availability for plants than the actual energy status per se.

70-71:03F-007
EFFICIENT BORDER IRRIGATION DESIGN AND OPERATION,
Howe, O. W., and Heermann, D. F.
Agricultural Research Service, Fort Collins, Colorado, Northern Plains Branch.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 1,
p 126-130, January-February 1970. 10 fig, 5 tab, 6 ref.

Descriptors: *Irrigation design, *Irrigation efficiency, *Irrigation operation and maintenance, *Border irrigation, *Design criteria, Irrigation engineering, Irrigation systems, Uniformity coefficient, Runoff, Soil texture, Slopes, Turnouts, Loam, Infiltration.
Identifiers: *Cutoff time, Stream size, Advance-regression curves.

Experiments were conducted on medium-and fine-textured loam soils in order to study the concept of optimum efficiency resulting from uniform intake opportunity times. The information was used to determine design and operation criteria for minimum runoff and maximum uniformity coefficient. The results indicated that for border irrigation under similar conditions uniformity coefficient is independent of input stream size within the 0.03 to 0.12 cfs per ft of border width range. The coefficient is also independent of slope in the low gradient range and for steeper slopes with close growing crops. 3 to 4 inches during the first 2 hours appears to be the minimum application depth for border irrigation that can be applied with high uniformity and minimum runoff. High uniformity was easier to obtain on the low gradients. Cutoff time was found to be the most crucial variable for efficient irrigation. Automatic turnout controls would be necessary if adaptation of border irrigation practice is accepted.

70-71:03F-008
RESPONSE OF AGRICULTURAL CROPS TO FLOODING, DEPTH-OF-WATER TABLE AND SOIL GASEOUS COMPOSITION,
Williamson, R. E., and Kritz, George J.
North Carolina State University, Raleigh, Dept of Soil Science
American Society Agricultural Engineers Transactions, Vol. 13, No. 2, p 216-220, March-April 1970. 5 p, 1 fig, 3 tab, 49 ref.

Descriptors: *Crops, *Agriculture, *Saturated soils, *Soil gases, Water table, Plants, Root development, Aeration.

Agricultural crops vary genetically and physiologically and thus require different soil water regimes for optimum production. To specify an optimum water-table depth, it is necessary to know at least the crop species, soil characteristics and watering procedure. Generally, grasses tolerate high water tables very well during cool seasons when the plants are dormant. Some crops such as strawberries are adversely affected by large fluctuations in the yearly water table (high in winter, low in summer). When a water table rises above some of the root system during a growing season and remains at a higher than normal level for more than one or two days, severe root pruning results. Experiments relating root function and plant performance to duration and extent of root system inundation should provide useful information for drainage design. Laboratory work has shown the root and shoot response of several plant species to various root zone gaseous compositions under varying conditions of temperature and radiant energy. Both in field and laboratory studies, relative to the problem of excess water and crop production, the air and water regime in relation to root function and total plant performance throughout its production cycle is the basic consideration. To restrict attention to the problem of excess water removal from a land area or to the specification of optimum water-table depths tends to abscure the real dimensions of the problem. Tables and curves relating data of the study are included.

70-71:03F-009
ESTIMATION AND USE OF WATER PRODUCTION FUNCTIONS IN CROPS,

Yaron, Dan.
Hebrew University, Rehovoth, Faculty of Agriculture.
Journal of Irrigation and Drainage Division, ASCE, Vol. 97, No. IR2, Proc Paper 8208, p 291-303, June 1971. 13 p, 2 fig, 4 tab, 19 ref, 1 append.

Descriptors: *Crop response, *Plants, *Water consumption, *Water supply, Agronomy, Irrigation, Planning, *Irrigation efficiency.
Identifiers: Crop yield, Empirical estimation.

By comparing two major theories regarding plant response to water supply and different soil moisture levels (Veihmeyer and Hendrickson; and Furr and Taylor, Hagan et al.), problems of empirical estimation of water production functions in crops were reviewed and the importance of the estimates was illustrated by several examples. The major problem of empirical estimation of such functions was their specification and in particular the choice of the independent variables, the dependent one being the crop yield per land unit. The paper concluded that while production functions with fixed intraseasonal water distribution could be estimated by regression methods, difficulties were involved in the regression approach in the estimation of dated production functions. An attempt to conceptualize the plant growth in the framework of process analysis, aimed at the derivation of growth rules was suggested.

70-71:03F-010
SCHEDULING IRRIGATIONS USING CLIMATE-CROP-SOIL DATA,
Jensen, Marvin E., Robb, David C. N., and Franzoy, C. Eugene.
Agricultural Research Service, Kimberly, Idaho, Snake River Research Center; Bureau of Reclamation, Denver, Colorado; and Salt River Valley Water Users' Association, Phoenix, Arizona.
ASCE Proceedings, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR1, Paper 7131, p 25-38, March 1970. 1 fig, 3 tab, 30 ref, append.

Descriptors: *Irrigation efficiency, *Irrigation engineering, *Irrigation practices, *Irrigation design, *Timing, Irrigation systems, Digital computers, Water management (Applied), Water utilization, Soil-water-plant relationships, Water distribution (Applied), Evapotranspiration.
Identifiers: Irrigation scheduling.

The most important factor affecting irrigation efficiencies and crop yields is scheduling irrigations in time and amount. Overirrigation may result in waterlogged soils, a condition which reduces yields and generally results in increased costs for water, fertilizer, and drainage. Water use is at a minimum when the amount of water applied is just equal to the consumptive use and the leaching requirement. To achieve higher irrigation efficiencies, present irrigation scheduling practices must be improved. Irrigation scheduling using climate-crop-soil data, computers to facilitate the tedious computations, and field observations by experienced personnel is a service that appears to be very attractive to the modern irrigation farm manager. This service has the potential of increasing the management skills of the farmer and his net return at a reasonable cost. It supplements the art of irrigation or experienced judgement with the results of recent advances in irrigation science.

70-71:03F-011
SUBSURFACE IRRIGATION EASILY AUTOMATED,
Davis, Sterling, Nelson, Sheldon D.
California University, Riverside, Agricultural Research Service.
ASCE Proceedings, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR1, Paper 7135, p 47-51, March 1970. 4 fig, 9 ref.

Descriptors: *Automation, *Irrigation design, *Subsurface irrigation, Irrigation engineering, Pipes, Automatic control, Mechanical control, Distribution systems.
Identifiers: Automated irrigation.

Subsurface irrigation applies water directly into the root zone of the crop and may easily be automated. Two subsurface irrigation systems are described: an automatic float-operated device to supply water needed to a tree or plants; and a plastic hose with inserts, planted with the potato seed and picked up with the mature potatoes.

70-71:03F-012
CLIMATIC ESTIMATES OF AVERAGE AND PROBABLE IRRIGATION REQUIREMENTS AND OF SEASONAL DRAINAGE IN CANADA,
Baier, W., and Robertson, George W.
Department of Agriculture, Ottawa (Ontario). Plant Research Institute.
Journal of Hydrology, Vol. 10, No. 1, p 20-37, January 1970. 18 p, 7 fig, 7 tab, 21 ref.

Descriptors: *Water demand, *Water requirements, *Irrigation water, *Hydrologic budget, Water balance, Climatology, Evapotranspiration, Precipitation (Atmospheric), Rainfall, Water allocation (Policy), Water management (Applied), Water distribution (Applied).
Identifiers: *Canada.

The use of published information to calculate average and probable irrigation requirements by means of a meteorological budgeting technique from 30-year daily climatic records is presented. This information, available for 59 stations across Canada, is useful for planning irrigation systems and interpretations of climate in terms of agricultural water needs and surplus. A seasonal drainage estimator model requiring as input only monthly values of precipitation and potential evapotranspiration was developed from the data for 42 stations and verified on the data for another 17 stations. An irrigation water balance is presented for 11 selected stations across Canada.

70-71:03F-013
EFFECTS OF WATER TABLE HEIGHT ON SOIL AERATION AND CROP RESPONSE,
Hiler, E. A., Clark, R. N., and Glass, L. J.
Texas A and M University, College Station, Dept of Agricultural Engineering.
American Society of Agricultural Engineers Transactions, Vol. 14, No. 5, p 879-882, September-October 1971. 8 fig, 1 tab, 11 ref.

Descriptors: *Soil-water-plant relationships, *Water table, *Lysimeters, Aeration, Drainage, Drainage effects, Crop response.
Identifiers: *Soil oxygen.

The first step for agricultural drainage design is determination of the drainage requirements of crops. Grain sorghum was grown in field lysimeters in which the water table was regulated automatically. Undisturbed soil cores which were one meter in diameter and two meters deep made up the lysimeters. Rainfall was kept off the lysimeters with a shelter system. Drastic reductions both in quantity and quality of grain sorghum yield occurred when water tables were maintained at 30 and 60 cm as compared to the 90- and 120-cm treatments. Reduced growth of grain sorghum occurred in general with the shallower water tables. Considerable crop oxygen stress occurred in the 30-cm treatment in which oxygen diffusion rates never exceeded 0.2 millionths of a g per sq cm per min in the root zone during the growing season; detrimental oxygen stress also occurred in the 60-cm treatment where oxygen diffusion rates in the crop root zone ranged from 0.4 to 0.9 millionths of a g per sq cm per min during the growing season. Leaf temperature and leaf diffusion resistance were not appreciably affected by oxygen deficiencies in the crop root zone.

70-71:03F-014
OPTIMAL DISTRIBUTION OF WATER TO IRRIGATION CANALS,
Muspratt, M. A.
McGill University, Montreal (Quebec).

Journal of Hydrology, Vol. 14, No. 1, p 19-28, October 1971. 3 fig, 10 ref, 2 append.

Descriptors: *Optimization, Distribution systems, Irrigation canals, Stochastic processes, Water, Histograms, Water utilization, Optimum use, Irrigation systems, *Water distribution (Applied), Nonlinear systems, Mathematical studies, Systems analysis, Monte Carlo method, Irrigation efficiency, *Irrigation practices.
Identifiers: *Deterministic model, Canada.

One of the principal problems of the irrigation planner is to determine the most efficient assignment of water to an irrigation canal network. Systems optimization based on mathematical programming is described for water assignment to irrigation canal networks with capacity constraints. Stochastic optimization is achieved by coupling deterministic linear programming with Monte Carlo simulation, including serial and cross correlations. In addition, posterior information may be considered by invoking Bayes' theorem. Nonlinear systems are also described.

70-71:03F-015
RESPONSE OF PLANT WATER POTENTIAL TO THE IRRIGATED ENVIRONMENT OF SOUTHRERN IDAHO,
Cary, J. W., and Wright, J. L.
Agricultural Research Service, Kimberly, Idaho. Snake River Research Center.
Agronomy Journal, Vol. 63, No. 5, p 691-695,
3 fig, 2 tab, 23 ref.

Descriptors: *Moisture tension, *Environmental effects, Irrigation, Moisture, Crops.
Identifiers: Beta-Vulgaris-D, Climate, Environment, Hordeum-Vulgaris-M, Irrigated, Medicago-Sativa-D, Micro, Moisture, Phaseolus-Vulgaris-D, Pisum-Sativum-D, Plant, Potential, Soil, Solanum-Tuberosum-D, Temperature, Transpiration, Triticum-Aestivum-M, Zea-Mays-M, Plant water potential, Southern Idaho.

Laboratory studies have shown that plant water potential affects a number of key processes involved in growth, but there has been almost no information on what levels of water potential occur under irrigated conditions in the field. Plant water potential in irrigated crops of Zea mays, Triticum aestivum, Hordeum vulgare, Phaseolus vulgaris, Pisum sativum, Solanum tuberosum, Beta vulgaris, and Medicago sative, L. was measured throughout the growing season in southern Idaho. Soil moisture conditions and potential evapotranspiration were monitored. Daily changes in plant water potential varied from less than 5 bars to more than 20 bars, while random sampling of supposedly homogeneous sets of plants showed an average variation of about 2 bars. Changes due to differences in soil moisture were also detected, even though the soil moisture potential was kept high enough for near-optimum crop production. Though the crops differed widely in their response to changes in environment, the plant water potential was strongly affected by microclimatic conditions. Day-to-day changes in plant water potential generally correlated more closely with changes in potential evapotranspiration than with changes in soil moisture content. Many of the daily changes observed in the plants remain unexplained, however. In general, the average water potential levels of all the field-grown plants were lower than levels reported from growth chamber studies. Potentials seldom rose above -8 bars and were never observed above -5 bars.

70-71:03F-016
APPLICATION OF THE PRINCIPLE OF CALCULATED RISK OF SCHEDULING SUPPLEMENTAL IRRIGATION: I. CONCEPTS,
Allen, W. H., and Lambert, J. R.
Tennessee University, Knoxville, Dept of Agricultural Engineering.
Agricultural Meteorology, Vol. 8, No. 3, p 193-201, 1971. 4 fig, 8 ref.

Descriptors: *Irrigation, *Scheduling, *Optimization, Risks, Model, Weather.
Identifiers: Calculated, Crop, Moisture, Principle, Production, Soil, Supplemental.

The concepts associated with applying the principle of calculated risk to irrigation scheduling are discussed. The basis for a general model for making daily decisions is formed by combining information relating crop production and available soil moisture with economic data and weather forecast data within a probability framework. The required inputs for such a model are discussed with respect to origin and form necessary to make the model operational. The resulting model makes each irrigation scheduling decision an attempt toward partial optimization of resource use and resulting economic gains or losses.

70-71:03F-017
APPLICATION OF THE PRINCIPLE OF CALCULATED RISK TO SCHEDULING OF SUPPLEMENTAL IRRIGATION. II. USE ON FLUE-CURED TOBACCO,
Allen, W. H., and Lambert, J. R.
Tennessee University, Knoxville, Dept of Agricultural Engineering.
Agricultural Meteorology, Vol. 8, No. 4/5, p 325-340, 1971. 6 fig, 8 tab, 5 ref.

Descriptors: *Scheduling, *Irrigation, *Risks, Model, Tobacco, Decision making, Environmental effects.
Identifiers: Daylength, Flue, *Model studies, Moisture, Precipitation, Simulation, Soil, Temperature, Transpiration.

A simulation model was constructed to test the application of an irrigation-scheduling decision model which incorporated the basic concepts of calculated risk. Inputs for the model included: the official probability precipitation forecasts for the periods today, tonight, and tomorrow; initial soil moisture content; daily precipitation; daily mean temperatures; daily potential evapotranspiration and daylength values; functions relating existing soil moisture content and stage of growth to the corresponding damage done to the crop; and cost of irrigation. The loss functions were developed specifically for flue-cured tobacco. Two methods were used for calculating the cost of the irrigation. The decision criterion was applied by means of the simulation model to data from 3 growing seasons. The results were compared to the results as arrived at by irrigating at a 50% available moisture depletion level. It was found that the new criterion (using either method for calculating the cost of irrigation) yielded less total cost plus loss and achieved a better utilization of the available water than did the 50% criterion. While the state of the art does not allow extremely well-based development of the input variables and parameters, available data have shown the concepts of the model to yield adequate results. Much future development of the approach remains, however.

70-71:03F-018
MODEL OF SOIL WATER USE BY TEA,
Willatt, S. T.
La Trobe University, Bundoora (Australia). School of Agriculture.
Agricultural Meteorology, Vol. 8, No. 4/5, p 341-351, 1971. 7 fig, 1 tab, 9 ref.

Descriptors: *Model, *Moisture deficit, *Consumptive use (water), Evaporation.
Identifiers: Deficit, Irrigation, Malawi, Moisture, Nyasaland, Soil, Tea-D, Yield.

The rate of water used by non-irrigated unpruned tea in Malawi depends on the soil water deficit although this rate was modified when the tea was pruned. Irrigated tea used water at a fairly constant rate of 0.9 Eo (open water surface evaporation) although some modification occurred due to weather factors. The results of sampling for water use were employed to produce a model for predicting water status of tea soils. Yield in September, October, and November were well correlated with water deficit at the beginning of each month.

70-71:03F-019

RELATIONS BETWEEN FE IN IRRIGATION WATER AND LEAF QUALITY OF CIGAR WRAPPER TOBACCO,

Rhoads, F. M.
Agricultural Research and Educational Center, Quincy, Florida.
Agronomy Journal, Vol. 63, No. 6, p 938-940, 1971. 3 fig, 3 tab, 5 ref.

Descriptors: *Irrigation effects, *Leaves, Tobacco, Iron, Manganese.
Identifiers: Algae, Cigars, *Irrigation, *Crop production, Nicotiana tabacum D, Relations, Tensile strength.

Damage, appearing to result from irrigation water, reduced the value of cigar wrapper tobacco (Nicotiana tabacum L.) in 1969. Dark leaf tips and dark spots over the entire leaf rendered damaged leaves unfit for wrapper use. Leaf analysis indicated that Fe and Mn were associated with the dark coloration. A study was made in 1970 to determine the effect of Fe in irrigation water on quality of cured wrapper tobacco leaves and to find a potential source of Fe contamination of irrigation ponds. Two forms of Fe were added to irrigation water applied to field plots, and Fe content of leaves, leaf quality, and leaf tensile strength were used to evaluate the effects. Soil and organic material were collected from a shallow area of a 'problem' pond, after it had been drained, for use in laboratory studies. Damaged tobacco, similar to that observed in commercial fields, was produced in field plots in 1970 when Fe was added to the irrigation water. Laboratory incubation studies showed that pond sediments were a potential source of Fe buildup in irrigation water. Leaf strength decreased with increasing content of Fe in the tissue. A visible coating was produced on green leaves in the greenhouse when 5 and 10 ppm Fe in water were sprayed on the plants.

70-71:03F-020

EFFECT OF TWO GROWTH-REGULATING CHEMICALS ON YIELD AND WATER USE OF THREE PERENNIAL GRASSES,

Mathias, E. L., Bennett, O. L., Jung, G. A., and Lundberg, P. E.
Agricultural Research Service, Morgantown, West Virginia.
Agronomy Journal, Vol. 63, No. 3, p 480-483, 1971. 8 fig, 2 tab, 6 ref.

Descriptors: *Yield, *Retardant, *Crop response, Chemical compounds, Grasses, Growth rate.
Identifiers: Bromus-Inermis-M, Cycocel, Damage, Etiolation, Festuca-Elatior-M, Foliar, N, Perennial, Poa-Pratensis-M, Pyrrolidino, Regulating, Succinamic-Acid.

Growth responses of smooth bromegrass (Bromus inermis Leyss), Kentucky-31 tall fescue (Festuca elatior L.), and common Kentucky bluegrass (Poa pratensis L.) to the growth-regulating chemicals F-529 (N-pyrrolidinosuccinamic acid) and Cycocel (2-chloroethyl-trimethylammonium chloride) were studied. Growth of grasses was reduced to near zero when Cycocel was applied at a concentration of 0.584 M, with at least some retardation occurring up to 100 days after application. F-529 was less effective than Cycocel in retarding grass growth. Maximum reduction occurred at the 0.45 M concentration where growth was reduced to 35% of the control, and at 70 days following application there was no reduction. Recovery from both chemicals was generally followed by a period of stimulated growth. Water use, in general, was highly correlated with amount of top growth. Food reserves of plants as determined by etiolated growth were significantly reduced only at the 0.292 M and 0.584 M concentration of Cycocel, where severe foliar damage had occurred.

70-71:03F-021

RESPONSE OF ALFALFA VARIETIES TO DIFFERENT WATER TABLE DEPTHS AT VARIOUS STAGES OF GROWTH,

Rai, S. D., Miller, S. A., and Hittle, C. N.
Illinois University, Urbana, Dept of Agronomy.
Agronomy Journal, Vol. 63, No. 2, p 331-333, 1971. 2 fig, 2 tab, 5 ref.

Descriptors: *Growth stages, *Water level, Alfalfa, Moisture content.
Identifiers: Depths, Medicago-Sativa-D.

Two cultivars of alfalfa, Medicago sativa L., 'Kentucky Syn. Z sub 1' and 'Narragansett' were grown in glazed tiles 90 cm deep with water tables of 15, 30, and 45 cm from the surface. When the water tables were raised immediately after the harvest, the dry matter yield was drastically reduced in both varieties. No significant yield difference was found when the treatments were applied 14 or 28 days after harvest. The highest yield was obtained when water table was held 45 cm from the surface and when applied 14 or 28 days after harvest.

70-71:03F-022
SOIL WATER EXTRACTION BY N-FERTILIZED SPRING WHEAT,
Bond, J. J., Power, J. F., and Willis, W. O.
Agricultural Research Service, Mandan, North Dakota. Soil and Water Conservation Research Division.
Agronomy Journal, Vol. 63, No. 2, p 280-283, 1971. 2 fig, 2 tab, 17 ref.

Descriptors: *Absorption, *Nitrogen, *Consumptive use (water), Wheat, Fertilizer, Soil water, Soil.
Identifiers: Extraction, Spring.

Field experiments were conducted to determine the effect of applied N on water use by continuously cropped spring wheat. Applied N increased vegetative growth and soil water extraction prior to heading. In 2 of the 3 sample years, this extraction of the soil water reserve resulted in less soil water extraction after heading by the N-fertilized crop than by nonfertilized crop. Applied N did not increase depth of soil water extraction. Overwinter recharge of soil water was inversely related to soil water content at harvest.

70-71:03F-023
RAPID FIELD MEASUREMENT OF LEAF WATER POTENTIAL IN SOYBEAN,
Boyer, J. S., and Ghorashy, S. R.
Pahlavi University, Shiraz (Iran). Dept of Crop Science.
Agronomy Journal, Vol. 63, No. 2, p 344-345, 1971. 2 fig, 12 ref.

Descriptors: *Moisture tension, *Measurement, Soybeans, Leaves.
Identifiers: Bean-D, Field, Glycine-Max-D, Potential, Soy, Leaf water potential.

Leaf water potentials of soybeans (Glycine max L. Merr.) were compared by 2 methods, the pressure chamber and the thermocouple psychrometer. A correlation coefficient of 0.957 was found for the 2 methods at leaf water potentials ranging from -3 to -25 bars. The pressure chamber method was used to measure the leaf water potential of several hundred soybean plants in different cultural studies in 1969 at Urbana, Illinois and found to be a rapid, efficient method.

70-71:03F-024
PERENNIAL IRRIGATED PASTURES: I. PLANT, SOIL WATER, AND ANIMAL RESPONSES UNDER ROTATIONAL AND CONTINUOUS GRAZING,
Raguse, C. A., Henderson, D. W., and Hull, J. L.
California University, Davis. Dept of Water Science.
Agronomy Journal, Vol. 63, No. 2, p 306-308. 1971. 2 fig, 3 tab, 9 ref.

Descriptors: *Irrigation, *Pasture, *Crop response, *Grazing, Rotation grazing, Continuous grazing.
Identifiers: Animal, Clover-D, Dactylis-Glomerata-M, Grass-M, Ladino, Lolium-Perenne-M, Orchard, Perennial, Plant, Rye, Soil, Strawberry, Trifolium-Fragiferum-D, Trifolium-Repens-D.

Continuous grazing favored strawberry clover (Trifolium fragiferum L. 'Salina'), and rotational grazing (5-field; 1-wk grazing, 4-wk recovery) favored Ladino clover (T. repens L.) in a sward containing Ladino clover, 'Salina' strawberry clover, orchard-grass (Dactylis glomerata L.),and perennial ryegrass (Lolium perenne L.). A 2-field rotation (1-wk, 1-wk) favored strawberry clover but had less influence on botanical composition than either 5-field rotation or continuous grazing. Continuous grazing resulted in a higher percentage of plant cover than did 5-field rotational grazing. Yields of beef per unit area were similar under the 3 systems. Water infiltration increased progressively during the 4 yr of the experiment, and final infiltration rates were 2-3 cm/hr in both continuous and rotationally grazed pastures.

70-71:03F-025
DISTRIBUTION OF P, K, Ca, Mg, B, Cu, Mn, AND Zn IN PEANUT LINES NEAR MATURITY,
Hallock, D. L., Martens, D. C., and Alexander, M. W.
Tidewater Research Station, Holland, Virginia.
Agronomy Journal, Vol. 63, No. 2, p 251-256, 1971. 2 tab, 2 fig, 12 ref.

Descriptors: *Nutrients, Chemical properties, Peanuts.
Identifiers: Nutrient distribution, Peanuts (Arachis hypogaea L.).

The nutrient contents of peanuts (Arachis hypogaea L.) grown under nutrient-sufficient conditions were determined in relation to yields of lines derived from 15 cultivars. Four plant portions of the lines, each a single seed selection, representing four market types were analyzed for contents of eight nutrients. In general, the fruit was highest in P and Zn contents and lowest of the four portions in K, Ca, Mg, B, Mn, and Cu contents. The upper central stem leaves were highest in Ca, Mg, Mn, and B contents and intermediate in P, K, Zn, and Cu contents. The first lateral branch leaves were highest in K content, intermediate in P, Ca, Mg, B, and Cu contents and lower in Zn content than the above portions. Copper content was highest and P content lowest in the hypocotyl whereas the other nutrient contents in this portion were generally higher than in the fruit portion only. Lines of the large-seeded Virginia type were generally highest in K, Ca, and B contents, intermediate in Mg content, and lowest in P content of the four types. The small-seeded Virginia type lines were highest in Mg content, equivalent in Cu and Mn content to the large-seeded lines, and intermediate in P and K contents. The Spanish and Valencia lines were highest in P content, lowest in Cu content, but equivalent in the small-seeded Virginia lines in K, Ca, B, and Mn contents.

70-71:03F-026
CROP RESPONSE TO EXCESSIVE ZINC FERTILIZATION OF ALKALINE SOIL,
Boawn, L. C., and Rasmussen, P. E.
Agricultural Research Service, Prosser, Washington.
Agronomy Journal, Vol. 63, No. 6, p 874-876, 1971. 4 tab, 1 fig, 6 ref.

Descriptors: *Crop response, *Saline soil, Zinc.
Identifiers: Zinc fertilization, Zinc toxicity.

The objective of this research was to evaluate the tolerance of economic plant species to excessive levels of available Zn in the soil. Fifteen field crop and three vegetable crop species were grown under uniform conditions in a growth chamber in alkaline soil treated with 10, 100, 200, 300, 400, 500 ppm Zn. Response was evaluated in terms of dry matter yield decrease (YD) and Zn concentration in tops. Grass species were most sensitive and had maximum YD's greater than 40%. Alfalfa (Medicago sativa L.), Alaska pea (Pisum sativum L.), Tomato (Lycopersicon esculentum Mill.), lettuce (Latuca sativa L.), spinach (Spinacia aleracea), and sugarbeet (Beta vulgaris L.) had YD's between 20 and 40%. Field bean (Phaseolus vulgaris L.), snap bean, russet potato (Solanum tuberosum L.), white potato, clover (Trifolium repens L.), and Perfection pea (Pisum sativum L.) did not undergo a significant YD. Zinc concentrations in tops associated with a 20% YD ranged from 240 ppm for field bean to 740 ppm for sugarbeet, with most crops falling in a 400 to 600 ppm range. The most sensitive species tolerated Zn additions of 200 to 300 ppm before undergoing a significant YD. Crops that underwent a significant YD because of excess Zn were stunted but showed no discoloration, malformation, or necrosis indicative of a direct metal toxicity.

70-71:03F-027

YIELD COMPONENTS AND WATER USE BY SILAGE CORN WITH IRRIGATION, PLASTIC MULCH, NITROGEN FERTILIZATION, AND PLANT SPACING,

Doss, B. D., King, D. C., and Patterson, R. M.
Agricultural Research Service, Thorsby, Alabama.
Agronomy Journal, Vol. 62, No. 4, p 541-543, 1970. 5 tab, 1 fig, 7 ref.

Descriptors: *Mulch, *Plant population, *Yield, Corn, Fertilizer, Nitrogen.
Identifiers: *Row width, *Water use efficiency, Plastic mulch, Nitrogen rate, Corn (Zea mays L.).

Corn was grown on a Lucedale fine sandy loam soil to determine the effects of irrigation, plastic mulch, N rate, row width, and plant population on yield components and water use by corn. Irrigation, plastic mulch, and higher plant population increased the dry matter yields of all plant parts. Closer row width increased dry matter yields of stalks and leaves but slightly decrease ear yields. Nitrogen rate had little or no effect on dry matter yields of any plant part. Stalks comprised an average of 45 percent of the total plant dry weight; ears, 36 percent; and leaves, 19 percent. Plastic mulch decreased average daily water use rates during the early part of the growing season but had little effect during the latter part of the season. Row width, plant population level, and N rate had little or no effect on water use rates. Daily water use rates during the season for unirrigated corn averaged 0.29 cm for plastic-covered plots and 0.31 cm for uncovered plots. Average rates for irrigated corn were 0.34 cm for plastic-covered and 0.47 cm per day for uncovered plots.

70-71:03F-028

SUMMER FALLOW SOIL WATER LOSSES ON INTERMOUNTAIN DRYLAND AND ITS EFFECT ON CROPPING WINTER WHEAT,

Massee, T. W., and Siddoway, F. H.
Snake River Conservation Research Center, Kimberly, Idaho.
Agronomy Journal, Vol. 62, No. 6, p 722-725, 1970. 2 tab, 4 fig, 6 ref.

Descriptors: *Tillage, *Water loss, Wheat, Germination, Root zone.

Intermountain drylands lose water from the root zone during the summer of fallow even though they receive a monthly average of 3.1 cm of precipitation. Soil water content in the 7.5- to 15-cm seed zone at the end of summer fallow was related to soil water content at the time tillage was initiated in the spring. Fall soil water content was not appreciably affected by variations in summer rainfall. Adequate soil water for winter wheat (Triticum aestivum L. em Thell) emergence was best assured by initiating summer fallow tillage when the water content in the 7.5- to 15-cm layer was relatively high, rather than depending on summer rain to rewet this layer.

70-71:03F-029

PREDICTING IRRIGATIONS FROM CLIMATIC DATA AND SOIL PARAMETERS,

Franzoy, C. E., and Tankersley, E. L.
Salt River Project, Phoenix, Arizona.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 6, p 814-816, 1971. 4 fig, 4 ref.

Descriptors: *Climatic data, *Scheduling, *Consumptive use, Irrigation efficiency, Irrigation, Soil.
Identifiers: Citrus-D, Climatic, Cotton-D, Forage, Grain, Irrigations, Oil, Parameters, Predicting, Radiation, Soil, Solar, Temperature, Vegetable.

The use of climatic data and soil parameters for scheduling irrigations provides control of the soil moisture reservoir essential for optimum yields. Need for efficient use of water is emphasized when water is scarce and costs are high or when soils exhibit poor water movement characteristics which drastically influence yields. Scheduling irrigations with a computer is an excellent supplement to, but not a replacement for, regular field visits. Frequent monitoring at moisture disappearance and replenishment through field observations by experienced personnel is an essential process for detecting variations in actual evapotranspiration and maintaining accurate predictions. On the basis of the results to date, the Jensen predictive approach offers a sound basis for predicting irrigation timing based on climatic data.

70-71:03F-030
PHOSPHORUS REQUIREMENTS FOR TOMATOES AS INFLUENCED BY PLACEMENT,
Hipp, B. W.
Texas A & M University, Weslaco, Texas, Agricultural Research and Extension Center.
Agronomy Journal, Vol. 63, No. 2, p 203-206, 1970. 3 tab, 5 fig, 8 ref.

Descriptors: Tomatoes, Phosphorus.
Identifiers: Tomato nutrition, Phosphorus application, Phosphorus requirement, Seeded tomatoes (Lycopersicon esculentum).

Field evaluations were made to determine the effectiveness of broadcast P versus P placed in a band for direct seeded tomatoes (Lycopersicon esculentum) on three soils common to South Texas and Northern Mexico. Broadcast P was ineffective in producing high yields when soil P levels were low enough that a P response was obtained. Phosphorus concentrations in young tomato plants were much higher with band P than broadcast P. Lateral distance of P placement from the seed row was critical in obtaining maximum early tomato growth. Depth of P placement was very important on clay soil but less so on sandy clay loam soil.

70-71:03F-031
TILLAGE AND CROP RESIDUE MANAGEMENT DURING SEEDBED PREPARATION FOR CONTINUOUS SPRING WHEAT,
Bond, J. J., Power, J. F., and Willis, W. O.
Agricultural Research Service, Mandan, North Dakota.
Agronomy Journal, Vol. 63, No. 5, p 784-792, 1971. 2 tab, 7 fig, 2 ref.

Descriptors: *Soil management, *Fertilization, *Tillage, Wheat, Land management, Planting management.
Identifiers: Wheat (Triticum aestivum L.), Seedbed preparation, Nitrogen fertilization.

Field experiments were conducted to determine the effect of four tillage and crop residue management methods of seedbed preparation on continuous spring wheat (Triticum aestivum L.) receiving four rates of applied N. Effects of tillage and surface-crop residues were separated by seedbed treatments of (a) conventional moldboard tillage, (b) conventional stubble mulch tillage, (c) moldboard tillage with part of the surface residue removed before and replaced after tillage. Treatments were evaluated relative to grain yields, yield components, dry-matter production, N uptake, soil nitrate content, soil temperature, plant water use and weed populations. For 3 of 4 years average grain yields (for all N rates) were 1,380, 1,060, 1,380, and 1,330 kg/ha for treatments a, b, c, and d, respectively. Yield reduction with stubble mulch tillage was related to poor weed control (primarily green foxtail) and not to the effects of surface residue per se. Use of fertilizer N failed to overcome yield reduction associated with stubble mulch tillage.

70-71:03F-032
FORAGE YIELD OF SWITCHGRASS (PANICUM VIRGATUM L.) IN PENNSYLVANIA,
Berg, C. C.

U.S. Regional Pasture Research Laboratory, University Park, Pennsylvania.
Agronomy Journal, Vol. 63, No. 5, p 785-786, 1971. 1 tab, 5 ref.

Descriptors: Switchgrass, Yield, Varieties.
Identifiers: Switchgrass (Panicum virgatum), Pennsylvania, Warm-season grass, Cool-season grass, Forage yield.

The production of forage by a warm-season grass species (switchgrass, Panicum virgatum L.) was compared with cool-season grasses in the cool, humid northeastern United States. Dry-matter yields were obtained from two varieties of tall fescue (Festuca arundinacea Schreb.) and orchardgrass (Dactylis glomerata L.) and three varieties of switchgrass in 1969. Two other varieties of switchgrass failed to become established and another two did not survive the first winter. Plots were harvested at approximately monthly intervals from May 15 to September 15, 1969. Orchardgrass and tall fescue began growing much earlier in the spring, continued to grow later in the fall, and produced 3,200 to 5,000 kg/ha more dry forage over the entire season than switchgrass. During midsummer the switchgrass varieties produced as much or more dry matter than the cool-season grasses; however, a high value must be placed on the production of forage at this time of year to justify considering switchgrass as a forage species in the cool humid northeastern United States. Yield data were limited to one harvest year (1969) because the switchgrass did not survive the following winter.

70-71:03F-033
GROWING BARLEY (HORDEUM VULGARE L.) ON BEDS IN SALINE SOIL,
Day, A. D., Turner, F. Jr., and Kirkpatrick, R. M.
Arizona University, Tucson.
Agronomy Journal, Vol. 63, No. 5, p 768-769, 1971. 3 tab, 9 ref.

Descriptors: *Saline soil, *Application method, *Application rate, Barley, Yield, Salinity, Weeds, Growth rate.
Identifiers: Barley (Hordeum vulgare L.), Barley culture.

Studies were conducted over a 2-year period at Safford, Arizona, to compare two methods (conventional drilling and two rows per bed) and two rates (28 and 56 kg/ha) of planting spring barley (Hordeum vulgare L.) on elevated beds in saline soil. Beds were oriented in two directions: north to south and east to west. Conventional drilling on beds resulted in both higher grain yields and grain volume-weights than did the two-row method of planting. Planting 56 kg/ha resulted in higher grain yields and volume weights than did planting 28 kg/ha. Grain yields were higher from barley grown on east-west beds than from barley grown on north-south beds. The two-row method of planting on beds resulted in more weeds than did the drilled method of planting. The research indicated that when barley was grown in saline soil, highest yields of quality grain were obtained when the crop was drilled at 56 kg/ha on east-west beds.

70-71:03F-034
GRAPHIC RELATION OF INTAKE, LENGTH-OF-RUN AND TIME,
Wu, I-pai, and Bishop, A. A.
Hawaii University, Honolulu, Agricultural Engineering Department.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR3, Proc. Paper 7506, p 233-240. 5 fig, 8 ref, 2 append.

Descriptors: *Graphical methods, *Infiltration, *Irrigation efficiency, *Surface irrigation, Irrigation, Irrigation practices.

The total amount of infiltration of surface irrigation expressed as a function of length of run and time is controlled by the advance function of stream inside the furrow (or border) and the infiltration characteristics of soils. Both the advance function and the infiltration intensity function can be expressed as a power function. There is a linear relationship between the time of advance and the opportunity time of infiltration with the total irrigation time as parameters. A simple graphic solution can be developed and used for estimating infiltration along the furrow (or border) at any given time during irrigation including the recession time. The technique is simple and requires no mathematical computation and can be used as a preliminary estimation of infiltration pattern or evaluation of an irrigation system. The shape of the infiltration pattern along the run can be used to determine the distribution efficiency and the application efficiency of surface irrigation.

70-71.03F-035
YIELD OF GRAIN LEGUMES AS AFFECTED BY IRRIGATION AND FERTILIZER REGIMES,
Horner, G. M., and Mojtehedi, M.
Agricultural Research Service, United States Department of Agriculture; and Tehran University, Tehran, Iran, College of Agriculture.
Agronomy Journal, Vol. 62, No. 4, p 449-450. 1970. 4 ref.
(See 70-71:02G-054)

70-71:03F-036
CONSUMPTIVE USE OF WATER BY ALFALFA IN WESTERN NEBRASKA,
Daigger, L. A., Axthelm, L. S., and Ashburn, C. L.
Nebraska Agricultural Experiment Station, Mitchell, Nebraska.
Agronomy Journal, Vol. 62, No. 4, p 507-508, 1970. 4 tabs, 7 ref.

Descriptors: *Alfalfa, *Consumptive use, *Moisture uptake, *Soil moisture, Water, Evapotranspiration, Water requirement.
Identifiers: Western Nebraska, Evapotranspiration ratio.

Consumptive use of water by alfalfa grown under two phosphorus fertility levels was measured in a 3-year study at the University of Nebraska Scotts Bluff Station, located in western Nebraska. Soil moisture to a depth of 230 cm was measured with a neutron moisture meter at the start of the growing season, after each cutting, and after the last harvest. Irrigation water was delivered to the benches through an underground pipe and measured before flood irrigation. Alfalfa used 11.4 cm water per metric ton (4.95 in/T) of 88% dry matter hay. Alfalfa used water more efficiently in early May and June than July and August. Average water use per day was 4.1 mm (0.16 in) for the first harvest, 5.6 mm (0.22 in) for the second harvest, and 5.9 mm (0.23 in) for the third harvest. Average evapotranspiration ratios for the 3-year period were 540 for the first cuttings, 630 for the second cuttings, and 860 for the third cuttings. The average evapotranspiration ratio for the three harvests over the 3-year period was 680. Two levels of phosphorus applied to the soil did not alter water use nor total yields of hay.

70-71:03F-037
INFLUENCE OF ROW SPACING, IRRIGATION, AND WEEDS ON DRYLAND FLAX YIELD, QUALITY, AND WATER USE,
Alessi, J., and Power, J. F.
Agricultural Research Service, Mandan, North Dakota.
Agronomy Journal, Vol. 62, No. 5, p 635-637. 2 tab, 2 fig, 14 ref.

Descriptors: *Supplemental irrigation, Irrigation, Yield, Weed control.
Identifiers: Seasonal water use, Flaxseed quality, Row spacing, Flax (Linum usitatissinum L.).

Field experiments were conducted during 1966 and 1967 at Mandan, North Dakota, to evaluate the effects of row spacing (7.5, 15, and 30 cm), irrigation water at fruiting, and weed competition (primarily from Setaria virilis) on water use by flax (Linum usitatissinum L.). An irrigation of 50 mm at the fruiting stage increased flaxseed yields only when weeds were controlled, particularly in the dry year of 1967. Flaxseed yields increased at row spacing narrowed from 30 to 7.5 cm only on unweeded plots. Weed growth reduced flaxseed yields for the 2-year period from 26 to 53%, with the least reduction from 7.5-cm row spacing. Midsummer rains or supplemental water at fruiting was less effective in increasing flaxseed production when weeds were present, but some degree of weed control was achieved with narrower row spacing. Oil content of flaxseed was not affected by treatments, but iodine number was slightly higher for the wider spacing (30 cm) in 1966. Total water use was not affected by row spacing or weed treatment, but water use efficiency was increased by narrow row spacing and by weed control. Water use patterns indicated deeper root penetration during the drier year.

70-71:03F-038
PREDICTING IRRIGATION REQUIREMENTS OF CROPS,
David, W. P., and Hiler, E. A.
Iowa State University, Ames, Dept of Agricultural Engineering.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR3, Proc. Paper 7507, p 241-255, 1970. 3 tab, 10 fig, 2 append, 20 ref.

Descriptors: *Model, *Soil moisture, *Rainfall, Cotton, Grain sorghum, Irrigation, Irrigation practices.
Identifiers: Probability theory.

A continuous soil moisture accounting model based on soil moisture depletion equations was developed. The model was adapted to an 18.6-acre experimental watershed and was used to estimate the monthly and seasonal irrigation requirements of both crops as based on a 30-yr sample were found to be normal. Weekly rainfall probabilities for the watershed were calculated from a 30-yr sample using the incomplete gamma density function. The use of weekly rainfall probabilities in irrigation planning is shown.

70-71:03F-039
FURROW IRRIGATION WITH DECREASING INFLOW RATE,
Lal, R., and Pandya, A. C.
Orissa University of Agriculture and Technology, Bhubaneswar, India, Dept of Agricultural Engineering and Technology.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR4, Proc. Paper 7748, p 451-460, 1970. 1 tab, 3 fig, 3 append, 11 ref.
(See 70-71:04A-011)

70-71:03F-040
AUTOMATIC CUTBACK FURROW IRRIGATION SYSTEM DESIGN,
Nicolaescu, I., and Kruse, E. G.
Colorado State University, Fort Collins.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, Proc. Paper 8358, p 343-353, 1971. 2 tab, 6 fig, 2 append, 7 ref.
(See 70-71:04A-012)

70-71:03F-041
MODEL FOR FARM IRRIGATION IN HUMID AREAS,
Windsor, J. S., and Chow, Ven Te.
Illinois University, Urbana.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, Proc. Paper 8355, p 369-385, 1971. 2 tab, 4 fig, 2 append, 14 ref.
(See 70-71:04A-013)

70-71:03F-042
IRRIGATORS SHAPE THEIR LAND FOR WATER CONTROL,
Garner, B. J.
Soil Conservation Service, Harlingen, Texas.
Soil Conservation, Vol. 36, No. 7, p 149-150, 1971.

Descriptors: Land, Irrigation, Water control.
Identifiers: Land leveling, Lower Rio Grande Valley.

Landowners shape their land for irrigation in the Lower Rio Grande Valley of Texas for better control of water. This means lower cost of labor for irrigating. It also means holding losses of water to a minimum. Leveling of fields makes possible the even distribution of irrigation water and rainfall, resulting in uniform crop growth. Land leveling must be designed in accordance with variations in soils, the crops to be grown, the water supply, and the method of irrigation in each case. The irrigators in this area have found that land leveling, plus good water management, has paid big dividends in conservation of irrigation water, retention of needed rainfall, lower costs, and more uniform and better crops.

70-71:03F-043
IRRIGATION SURVEY,
Irrigation Journal.
Irrigation Journal, Vol. 21, No. 5, p 10-17, September-October, 1971. 45 ref.

Descriptors: *Irrigation systems, *Irrigation practices, *Distribution systems.
Identifiers: *United States.

This article is a compilation of statistics on irrigation, state by state, through 1970 including sprinkler and gravity methods, types of power equipment, and the various types of pipes used in irrigation lines.

70-71:03F-044
SOIL - WATER RELATIONSHIP,
Irrigation Journal.
Irrigation Journal, Vol. 21, No. 5, p 6-9, September-October, 1971. 2 fig, 3 tab.

Descriptors: *Irrigation practices, *Crop production, Irrigated efficiency, Soil moisture, Available water, Excess water, Infiltration, Leaching, Moisture tension, Soil moisture meters, Soil-water-plant relationships, Tensiometers.
Identifiers: *Irrigation scheduling, *Irrigation research, Soil moisture measurements.

The use of water in irrigation, as in all walks of life, is receiving re-evaluation as emphasis on the total amount of water available for all uses becomes a more pressing problem. A few years ago, guesswork was the most common method of determining the need for additional water. Today, however, the question of when and how much to irrigate is getting the technical attention it deserves. This very general summary was presented to show that useful data are available throughout the country - data that should be used in the design and operation of irrigation systems.

70-71:03F-045
BOLD NEW DEVELOPMENT FOR IRRIGATION,
Bureau of Reclamation.
Reclamation Era, Vol. 56, No. 1, p 15-18, February, 1970. 3 fig.

Descriptors: *Irrigation practices, *Irrigation programs, Irrigation efficiency, Water conservation, Crop production, Groundwater.
Identifiers: *Irrigation scheduling, *Irrigation research, United States Bureau of Reclamation.

Irrigation scientists generally agree in existance of the paradox that: Irrigators are perennially concerned with too-short supplies of water yet too much water is applied to the fields under current watering practices. The result is a complex melange of wasted water, increased costs, reduced production, and lower farm efficiency. To strike at this contradiction, the Bureau of Reclamation has started a pilot program of scheduling irrigation wa water deliveries. Bureau personnel take soil moisture samples and deliver an irrigation schedule to the farmer. The results have been a 20 percent increase in crop yield with a 30 percent reduction in water use. Annual costs of 1 dollar per acre have produced benefits of $35 per acre.

70-71:03F-046
STARTING WITH TRICKLE IRRIGATION,
DeRemer, E. D.
Business Dynamics Corporation, Phoenix, Arizona.
Reclamation Era, Vol. 56, No. 4, p 15-17, November 1970.
(See 70-71:03C-009)

70-71:03F-047
IRRIGATION GUESSWORK - GOODBYE,
Cassai, N.
United States Bureau of Reclamation, Region 7, Denver, Colorado, Information Officer.
Reclamation Era, Vol. 56, No. 2, p 16-18, May 1970. 2 fig.

Descriptors: *Irrigation practices, *Irrigation programs, *Irrigation efficiency, Water conservation, Crop production, Groundwater, Wyoming, Nebraska.
Identifiers: *Irrigation scheduling, *Irrigation research, United States Bureau of Reclamation.

Studies in using the computer to predict when and how much to irrigate are being conducted by the United States Bureau of Reclamation. The tests, conducted during 1969, were on 363 acres near McCook, Nebraska and 260 acres near Torrington, Wyoming. The principal crops in the test areas were: corn, sugarbeets, beans, alfalfa and small grains. Due to diseases the previous year direct correlation of yields was impossible. However, there was a significant increase shown. The cost of the services, on a commercial basis, is estimated at between $1.50 and $4.00 per acre per year, depending on how much of the data is collected by the farmer. Water savings of from 10 to 15 percent were observed. Other benefits are: reduced labor costs, reduced fertilizer requirements, increased net returns, and fewer drainage problems.

70-71:03F-048
TRICKLE IRRIGATION. . . A MORE EFFICIENT MEANS OF WATER MANAGEMENT,
Lyons, C. G., Jr.
Texas Agricultural Extension Service, Welasco, Texas.
Texas Agricultural Progress, Vol. 18, No. 1, p 3-4, Winter, 1972. 5 fig.
(See 70-71:03C-010)

70-71:03F-049
MOISTURE SENSOR PLACEMENT FOR REGULATION OF FURROW-IRRIGATION SYSTEMS,
Myers, R. G., and Edwards, D. M.
Valmont Industries, Valley, Nebraska.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 303-306, March 1970. 5 fig, 16 ref.
(See 70-71:04A-019)

70-71:03F-050
AUTOMATION OF SURFACE IRRIGATION WITH FLUIDIC DIVERTERS,
Kruse, E. G., Freeman, P. A., and Haise, H. R.
United States Department of Agriculture, Fort Collins, Colorado, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 357-361, March 1970. 11 fig, 6 ref.
(See 70-71:08A-002)

70-71:03F-051
PRACTICALITY ESTABLISHED FOR TRAVELING SPRINKLER SYSTEMS,
Sisson, D. R.
L. R. Nelson Manufacturing Company, Incorporated, Illinois.
World Irrigation, Vol. 20, No. 2, p 15-16, March 1970. 1 fig, 2 tab.
(See 70-71:04A-022)

70-71:03F-052
CALIFORNIA DRIP-IRRIGATION TESTS MAY PROVE METHOD SIGNIFICANT,
Irrigation Journal.
Irrigation Journal, Vol. 21, No. 2, p 12-13, March-April 1971.
(See 70-71:03C-011)

70-71:03F-053
NEW FINDINGS ON THE USE OF TRICKLE IRRIGATION SYSTEMS IN THE UNITED STATES, AUSTRALIA & ISRAEL,
DeRemer, E. D.
Business Dynamics Corporation.
World Irrigation, Vol. 20, No. 6, p 14-16, December 1970. 4 fig, 1 tab.
(See 70-71:03C-012)

70-71:03F-054
HOW TO RECYCLE RUNOFF,
Coleman, C.
World Irrigation, Vol. 10, No. 3, p 20-24, April 1970. 2 fig.

Descriptors: *Water reuse, *Irrigation practice, *Irrigation efficiency, *Water conservation, Waste water, Water control, Water loss, Water pollution control, Irrigation engineering.
Identifiers: *Pump back systems, Irrigation automation.

The reuse of water is getting much attention in the United States today. One area that seems to show promise is that of recycling tailwater runoff in irrigated areas. By installing a collection pond and a pump back system it seems that irrigation efficiencies of 80 percent or greater are entirely possible. By not allowing water to waste off the end of the field the problem of silt and nutrient pollution in the streams could be greatly reduced. Also, in areas where urban development borders on agricultural land the legal problems associated with waste water could be eliminated.

70-71:03F-055
UNLINED MOLE LINES FOR IRRIGATION,
Norum, D. I., and Cray, D. M.
Saskatchewan University, Saskatoon, Canada.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5, p 661-668, May 1970. 3 fig, 1 tab, 11 ref.
(See 70-71:02G-079)

70-71:03F-056
PRESSURE DISTRIBUTION ON A CENTER-PIVOT SPRINKLER IRRIGATION SYSTEM,
Kincaid, D. C., and Heermann, D. F.
United States Department of Agriculture, Mitchell, Nebraska.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5,
p 556-558, May 1970. 3 fig, 5 tab, 5 ref.
(See 70-71:04A-030)

70-71:03F-057
EVAPOTRANSPIRATION AND DRAINAGE FROM THE ROOT ZONE OF IRRIGATED COASTAL BERMUDAGRASS ON COASTAL PLAINS SOILS,
Doss, B. D., and Taylor, H. M.
United States Department of Agriculture, Thorsby, Alabama.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 4,
p 426-429, April 1970. 5 fig, 4 tab, 10 ref.

Descriptors: *Soil-water-plant relationships, *Evapotranspiration, *Water conservation, Consumptive use, Evaporation, Transpiration, Drainage, Soil physics, Bermudagrass.
Identifiers: Water use.

Water contents as a function of time and depth were measured with a neutron meter on plastic-covered and on bermudagrass-vegetated Lucedale soil. Relations between drainage rates and water contents were developed for eight depth increments of the plastic covered profile. These were used to separate evapotranspiration from deep drainage losses. Evapotranspiration of Coastal bermudagrass at Thorsby, Alabama, was 0.8 cm per day for the second day after irrigation and decreased to 0.06 cm per day, 28 days after irrigation. The fraction of evapotranspiration from the upper 15 cm of soil decreased with time, but the fraction was constant or increased in all other horizons.

70-71:03F-058
CROP RESPONSE TO MIST IRRIGATION,
Howell, T. A., Hiler, E. A., and van Bavel, C. H. M.
Texas A & M University, College Station.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5,
p 906-910, May 1971. 8 fig, 3 tab, 17 ref.
(See 70-71:04A-031)

70-71:03F-059
STRESS DAY INDEX TO CHARACTERIZE EFFECTS OF WATER STRESS ON CROP YIELDS,
Hiler, E. A., and Clark, R. N.
Texas A & M University, College Station, Texas.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4,
p 757-761, April 1971. 2 fig, 2 tab, 28 ref.
(See 70-71:02G-082)

70-71:03F-060
OPERATION OF IRRIGATION SYSTEMS OUTSIDE THE GROWING SEASON,
Voropayev, G. V.
Soviet Hydrology: Selected Papers, No. 1, p 80-88, 1970. 6 fig, 4 tab.

Descriptors: *Irrigation systems, *Irrigation operation and management, *Surface irrigation, Irrigation practices, Water management, Distribution systems.
Identifiers: *Winter operation, Leaching.

A study was conducted to evaluate the possibility of operating an irrigation system under severe winter conditions. The area selected was in the Soviet Union

Union with winter temperatures below -10°. The purpose was to see if it was desirable to add additional irrigation and leaching water during the winter months. It was found that this method worked satisfactorily if the irrigation method used was equally efficient at adding water to the soil or forming surface ice layers.

70-71:03F-061
SQUARE-MATIC LATERALLY . . . NEW CONCEPT IN SPRINKLER IRRIGATION ACHIEVES GOALS LONG SOUGHT BY FARMERS,
R. M. Wade & Company, Portland, Oregon.
Irrigation Journal, Vol. 21, No. 2, p 10-11, March-April 1971. 1 fig.
(See 70-71:04A-047)

70-71:03F-062
SEASONAL VARIATION OF HYDRAULIC PARAMETERS AND THEIR INFLUENCE UPON SURFACE IRRIGATION APPLICATION EFFICIENCY,
Linderman, C. L., and Stegman, E. C.
United States Department of Agriculture, Lincoln, Nebraska, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5, p 914-923, May 1971. 10 fig, [illegible] tab, 11 ref.
(See 70-71:04A-035)

70-71:03F-063
ELECTRIC CONTROLS FOR AUTOMATIC SURFACE IRRIGATION SYSTEMS WITH REUSE SYSTEM,
Fischbach, P. E., Thompson, T. L., and Stetson, L. E.
Nebraska University, Lincoln.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 286-288, March 1970. 10 fig, 3 ref.
(See 70-71:04A-038)

70-71:03F-064
THE HYDRAULICS OF AN AUTOMATED FURROW IRRIGATION SYSTEM WITH RECTANGULAR SIDE WEIR OUTLETS,
Sweeten, J. M., and Garton, J. E.
Oklahoma State University, Stillwater.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 6, p 746-751, June 1970. 12 fig, 1 tab, 17 ref.
(See 70-71:04A-039)

70-71:03F-065
GET DOUBLE USE OUT OF IRRIGATION WATER,
Bondurant, J. A.
United States Department of Agriculture, Kimberly, Idaho. Agricultural Research Service, Snake River Conservation Research Center.
Idaho Farmer, Vol. 88, No. 6, p 24-27, March 1970.

Descriptors: *Water reuse, *Irrigation practices, Irrigation efficiency, Water conservation, Waste water, Water control, Water loss, Water pollution control, Irrigation engineering.
Identifiers: *Pump back systems, Irrigation automation.

The reuse of water is getting much attention in the United States today. One area that seems to show promise is that of recycling tailwater runoff in irrigated areas. By installing a collection pond and a pump back system it seems that irrigation efficiencies of 80 percent or greater are entirely possible. By not allowing water to waste off the end of the field, the problem of silt and nutrient pollution in the streams could be greatly reduced. Also, in areas where urban development borders on agricultural land the legal problems associated with waste water could be eliminated.

70-71:03F-066
EFFICIENCIES OF AN AUTOMATED SURFACE IRRIGATION SYSTEM WITH AND WITHOUT A RUNOFF RE-USE SYSTEM,
Fischbach, P. E., and Somerhalder, B. R.
Nebraska University, Lincoln.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4, p 717-719, April 1971. 4 fig, 2 tab, 8 ref.
(See 70-71:04A-045)

70-71:03F-067
SYSTEMS APPROACH TO DESIGN OF SPRINKLER IRRIGATION,
Liang, T., and Wu, I. P.
Hawaii University, Honolulu.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5, p 618-621, May 1970. 11 fig, 19 ref.

Descriptors: *Irrigation practices, *Sprinkler irrigation, Design criteria, Computer programs, Optimization.

A method of designing a solid set sprinkler system while optimizing the economy has been developed. The procedure is in the form of a digital computer program. The program is presented along with the procedure used in its development and method limitations. The program was tried on an actual design problem and the results presented.

70-71:03F-068
GRAIN SORGHUM RESPONSE TO NUMBER, TIMING, AND SIZE OF IRRIGATIONS IN THE SOUTHERN HIGH PLAINS,
Musick, J. T., and Dusek, D. A.
United States Department of Agriculture, Bushland, Texas.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3, p 401-404, March 1971. 2 fig, 2 tab, 11 ref.

Descriptors: *Irrigation practices, *Supplemental irrigation, Irrigation effects, Irrigation efficiency.
Identifiers: Irrigation timing.

A limited irrigation approach to irrigating grain sorghum in the Southern High Plains involving reducing (a) number of irrigations applied in relation to stage of plant development, and (b) size of irrigation was studied. The study consisted of a 3-year detailed plot study and a 3-year graded furrow field test. The most efficient use of one 4-in. seasonal irrigation resulted from applying water at the heading stage. Plant moisture stress during vegetative development had less effect on yields than stress during heading. At higher water levels, irrigation vegetative development became more important to obtaining high yields and efficient water use. Reducing size of seasonal irrigations from 4- to 2-in. reduced yields but increased irrigation water use efficiency. The average increase for 9 treatment year comparisons was from 335 to 511 lb. per acre-in.

70-71:03F-069
RETURNED PROFITS,
Irrigation Age, Vol. 4, No. 9, p 20-21, April 1970. 8 fig.

Descriptors: *Water re-use, *Irrigation practices, Irrigation efficiency, Water conservation, Waste water, Water control, Water loss, Water pollution control, Irrigation engineering.
Identifiers: *Pump back systems, Irrigation automation.

The question of why return water is dealt with, by listing examples. Cost figure of $3,333.60 was given for a return system with a storage capacity of 1 acre-foot and 1,296 feet of pipeline for the Texas high plains area. An explanation of what a return system is, was given.

70-71:03F-070
SALT RIVER PROJECT'S COMPUTERIZED IRRIGATION,
World Irrigation, Vol. 20, No. 6, p 17, December 1970. 1 fig.

Descriptors: *Irrigation practices, *Irrigation programs, Irrigation efficiency, Water conservation, Crop production.
Identifiers: *Irrigation scheduling, Irrigation research, Irrigation engineering.

Irrigation scheduling research is being conducted on the Salt River Project. Sample soil cores are collected in the field and brought to the laboratory for analysis. The information is then fed into the computer. The result is a print out that tells the farmer when and how much water to apply. Cotton yields have been increased by 250 pounds per acre. Water savings are reported in excess of 10 percent. Personal contact with the farmer has proven much more effective than mailing out the information.

70-71:03F-071
NEED FOR CONTROLLING SALINITY OF THE COLORADO RIVER,
Colorado River Board of California.
Colorado River Board of California, Los Angeles, California, State of California.
Report, August 1970. 89 p. 10 fig, 12 tab, 32 ref, 1 append.
(See 70-71:05G-020)

70-71:03F-072
THE MINERAL QUALITY PROBLEM IN THE COLORADO RIVER BASIN,
Regions VIII and IX, U.S. Environmental Protection Agency.
United States Environmental Protection Agency, Regions VIII and IX,
Report, Regions VIII and IX, 1971. 9 fig, 9 tab, 4 append.
(See 70-71:05C-015)

SECTION XVI

WATER QUANTITY MANAGEMENT AND CONTROL

CONTROL OF WATER ON THE SURFACE (Group 04A)

70-71:04A-001
BENTONITE SEALING METHODS COMPARED IN THE FIELD,
Rollins, Myron B., and Dylla, Anthony S.
Bureau of Land Management, Prineville, Oregon; and Agricultural Research Service, Reno, Nevada.
Proceedings of the American Society of Civil Engineers, Journal of the Irrigation Drainage Division, Vol. 96, No. IR2, p 193-203, June 1970. 11 p, 8 tab, 8 ref, append.

Descriptors: *Bentonite, *Reservoirs, *Reservoir leakage, *Sealants, *Soil sealants, Methodology, Field tests, Blankets, Seepage, Sands, Protective coatings, Linings, Construction costs, Irrigation canals, Costs, Buried membranes, Clays.
Identifiers: *Small reservoirs, *Small impoundments, *Seepage control.

Twelve small reservoirs were constructed at each of 2 sites in western Nevada to test methods of sealing with bentonite. Utah bentonite was installed as the following types of seals: (1) waterborne-harrowed, (2) waterborne-over-a-gravel surface, (3) surface blanket, (4) buried blanket, and (5) buried membrane. The waterborne-harrowed seals were short lived. The waterborne seals on reservoirs with graveled surfaces were effective only slightly longer, becoming ineffective after the third season. The 4-in. surface blanket seals were more durable, their effectiveness lasting about 5 seasons. The buried blanket and buried membrane seals proved to be the best, retaining 60% effectiveness 6 yr after installation. Costs of bentonite sealing varied from $0.20 to $1.30/sq yd of soil surface, and are comparable with other methods of sealing, such as plastics.

70-71:04A-002
HODOGRAPH SOLUTION OF THE DRAINAGE PROBLEM WITH VERY SMALL DRAIN DIAMETER,
Youngs, E. G.
Agricultural Research Council, Cambridge (England). Unit of Soil Physics.
Water Resources Research, Vol. 6, No. 2, p 594-600, April 1970. 7 p, 3 fig, 2 tab, 11 ref.

Descriptors: *Drainage, *Soil water movement, *Groundwater movement, *Subsurface drainage, Drawdown, Capillary water, Drainage systems, Mathematical studies.
Identifiers: Hodographs.

The hodograph treatment of the drainage problem of uniform vertical fluxes draining to a system of parallel equally spaced cylindrical drains laid in an infinitely deep soil is applied to the case of very small drains. A simple approximate expression allowing the inclusion of the effect of the capillary fringe thickness is derived for the drain radius. Computed results are presented, and these are used in the discussion of experimental results for systems of gappy drains laid in a hydraulic model sand tank.

70-71:04A-003
ESTIMATION OF UNCONFINED GROUND WATER FLOW TO DITCHES,
Venetis, C.
Dievd. Technikon Ypiresion, Ioannina (Greece).
Journal of Hydrology, Vol. 13, No. 4, p 338-342, September 1971. 5 ref.

Descriptors: *Groundwater movement, *Ditches, *Drainage systems, Water levels, Drawdown, Equations, Mathematical studies, Discharge (Water), Water yield, Infiltration, Water table.
Identifiers: *Drainage ditches.

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Prediction of groundwater flow to drainage ditches is of some practical importance in drainage studies. Simple formulae are based on the well known linear differential equation of groundwater flow. They enable a quick step by step computation of groundwater flow corresponding to any assumed infiltration sequence uniformly distributed over the basin under study. The single parameter in the formulae, which lumps the physical and geometric properties of the aquifer, can be easily determined from an observed recession of groundwater levels or groundwater discharge. Thus estimates of the physical parameters of the aquifer are not necessary for the application of the approach.

70-71:04A-004
TRANSIENT FLOW BETWEEN PARALLEL DRAINS.
Yeh, William Wen-Gong, and Singh, Rameshwar.
California University, Los Angeles; and San Jose State College, California.
Journal of Hydrology, Vol. 11, No. 3, p 301-312, September 1970. 12 p, 12 fig, 1 tab, 7 ref.

Descriptors: *Subsurface drainage, *Unsteady flow, *Groundwater movement, *Mathematical studies, *Computer programs, Linear programming, Soil water movement, Drainage systems, Hydraulic conductivity, Specific yield, Dupuit-Forchheimer theory, Permeability, Drawdown.
Identifiers: Transient groundwater flow.

The problem of transient-flow subsurface drainage between parallel drains has been solved by the method of weighted-residuals. The assumption of an initial profile is removed in this method. The governing nonlinear partial differential equation is reduced to ordinary differential equations which are easily solvable on the computer. The solution is presented in two nondimensional graphical forms for easy field application.

70-71:04A-005
REGION 7 LAUNCHES PROGRAM TO REDUCE SUBSURFACE DRAIN COSTS,
Lidster, W. A.
Bureau of Reclamation, Denver, Colorado.
Reclamation Era, Vol. 57, No. 4, p 14-20, November 1971. 7 fig.

Descriptors: *Subsurface drains, *Polyethylene, Drains, Construction methods, Drain spacing, Average costs, Construction equipment, Field investigations, Construction, Construction practices, Field tests, Drain tiles, Plastic pipes, Cost comparisons, Depth.
Identifiers: *Drainage costs, *Plastic tubing, *Excavators, Trench width, Cost curves, Bureau of Reclamation (Region 7).

To reduce the cost of subsurface drainage work, the Bureau of Reclamation has undertaken a program to investigate new pipe materials and equipment. The average cost of recent subsurface drains in Region 7 is $32,000 per mi. Phase 1 consisted of installing and evaluating corrugated, perforated, polyethylene drainage tubing. Some advantages of this tubing over concrete or clay draintile are: (1) is easy to handle; (2) can be manufactured in long lengths; and (3) requires less manpower for installation. Two test reaches of polyethylene tubing were installed in Nebraska by a trencher and pipe laying machine. The installation rate for these reaches was about 4 ft/min, 2 to 3 times faster than for equivalent lengths of concrete or clay pipe. Phase 2 was to locate a machine capable of laying tubing at a faster rate. One machine having this potential is a German-made, Hoes Gigant trencher, used in a field demonstration near Courtland, Kansas, to install 2,000 ft of polyethylene tubing. The drains were installed 7.5 ft deep, with gravel envelope, at an average rate of 15 ft/min. This demonstration indicated that by using new pipe materials and high speed trenching machines, drainage costs may be reduced.

70-71:04A-006
IRRIGATION AND DRAINAGE: SECTION II. ORGANIZATION,
Willson, R. J.
American Society of Civil Engineers, Committee on Operation and Maintenance of Irrigation and Drainage Systems of the Irrigation and Drainage Division.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR4, Proc. Paper 8613, p 601-633, 1971. 2 fig, 2 ref, 1 append.

Descriptors: *Drainage, *Maintenance, *Organizations, *Water management, *Construction, *Irrigation, Operations, Personnel, Water resources.
Identifiers: Public land policy, Organization charts, Public opinion.

As an irrigation or drainage system is constructed, the transition toward its intended function begins. The organization to perform this function centers around operation and maintenance personnel; however, additional construction functions may be included until project completion. This section of the manual reviews the organizational systems having this responsibility. The function of the policy-setting bodies and operating personnel, together with methods for accomplishing their responsibilities, are also reviewed.

70-71:04A-007
MANAGEMENT STRUCTURE FOR IRRIGATION,
Smith, R. A.
United Water Conservation District of Ventura City, Ventura City, California.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR4, Proc. Paper 7722, p 475-488, 1970. 2 fig, 18 ref, 1 append.

Descriptors: *Engineers, *Management operation, *Personnel, *Planning, Communication, Ethics, Irrigation, Maintenance, Organizations, Policy.

After engineers build irrigation systems many continue as operators and changing to managers by acquiring the concepts and skills of management. This involves shifting from doing work to responsibly supervising others. The physical irrigation system hosts an intricate social structure which utilizes the democratic process to establish policy and to govern operations within a framework of law. Human functions supercede equipment and both require ever-improving techniques of operation. Vitalized operations result from the constant quest for improvement. Continual attention must be given to better management methods in order for an irrigation system to effectively perform its intended function. Methods include good communication, careful planning and effective control. Engineers with good personal qualifications can become increasingly effective in motivating subordinates toward better performance by sharpening skills in a self-development campaign. Engineers as managers can thus improve in ability to sponsor proper relationships with board members and others. This leads to an improved acceptance of irrigation system objectives by the public.

70-71:04A-008
OPTIMAL DESIGN OF FURROW LENGTH OF SURFACE IRRIGATION,
Wu, I-pai, and Liang, Tung.
Hawaii University, Honolulu, Agricultural Engineering Department.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR3, Proc. Paper 7543, p 319-332, 1970. 1 tab, 5 fig, 12 ref, 2 append.

Descriptors: *Furrow drainage, *Furrow irrigation, *Optimization, *Surface irrigation, *Systems analysis, Irrigation, Irrigation efficiency.
Identifiers: Furrow length.

The furrow length design of an irrigation system can be optimized by analyzing overall irrigation system cost when the infiltration intensity function soils, advance function of inflow stream inside the furrow, and other pertinent information are known. Computer programs were coded for obtaining optimal solution. The curves of cost functions usually have gentle slope close to optimum furrow length when stream size is fixed (advance function known). Therefore, the designer does have limited freedom of choosing a suitable furrow length without incurring extremely high cost. The length of furrow which falls in the interval where cost vary less or equal to 5 percent of the optimal or the minimum cost is defined arbitrarily as adequate length. Results showed that the irrigation application efficiency is a function of furrow length. Comparison of ordinary system and a cutback system was also conducted. The developed optimization technique can also be used to determine the length of the border.

70-71:04A-009
DEVELOPMENT OF AUTOMATION ON SALT RIVER,
Shipley, H.
Salt River Project, Phoenix, Arizona.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR2, Proc. Paper 7373, p 151-163, 1970. 13 fig.

Descriptors: *Automatic control, *Irrigation practices, Remote control, Analog computers, Canal design, Digital computers, Gates, Irrigation, Irrigation engineering, Irrigation operation, Irrigation systems, Pumps.
Identifiers: Salt River Project.

Workload studies and efficiency evaluation of water deliveries plus savings of pump costs justify the installation of automatic supervisory control for irrigation facilities and deepwell pumps. Due to the fact that the Salt River Project irrigation system is the oldest multipurpose irrigation project in the United States and is now in the transition of converting many of the farm lands into urban development, new problems have been created, making this type of installation feasible. The hydraulic design of the gates and changes in operation of the delivery system have been thoroughly studied and integrated into the application of the remote supervisory control.

70-71:04A-010
AUTOMATION FOR SMALL IRRIGATION PROJECTS,
Mann, T. E.
Bureau of Reclamation, Bismarck, North Dakota.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, Proc. Paper 8344, p 501-513, 1971. 3 fig, 3 ref, 1 append.

Descriptors: *Automation, *Telemetry, Conservation, Costs, Gates, Irrigation, Maintenance, Radio, Reclamation, Reservoir, Water supply.
Identifiers: Southwestern Montana.

A remote control and data telemetering system has been installed on a 21,800-acre irrigation project in southwestern Montana. After 3 years of operation of the initial installation very little maintenance has been required for the audio-frequency-tone-control type radio equipment. This system allows for opening and closing outlet gates and receiving gate position and water level readings by remote operation from headquarters. Elimination of requirement for dam tender and residence with resultant savings made installation of equipment economically feasible. Quick appraisal of water levels and flow provides smoother operation of irrigation releases, conserves water, and requires less travel and overtime for the water master. Performance of the system will be used in later designs of automation equipment and for operation of this equipment on large irrigation projects.

70-71:04A-011
FURROW IRRIGATION WITH DECREASING INFLOW RATE,
Lal, R., and Pandya, A. C.

Orissa University of Agriculture and Technology, Bhubaneswar, India, Dept of Agricultural Engineering and Technology.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR4, Proc. Paper 7748, p 451-460, 1970. 1 tab, 3 fig, 3 append, 11 ref.

Descriptors: *Furrows, *Inflow, *Reduction, Agricultural engineering, Design, Irrigation.
Identifiers: Time dependence.

A mathematical model has been developed to provide the manner in which the inflow stream size at the upstream end of a furrow must be reduced stepwise according to the infiltration characteristics of the soil so as to eliminate runoff losses from the downstream end and keep the deep percolation losses to the minimum. Owing to the high infiltration rate in the beginning the initial stream size may be large and kept constant till water reaches the end of furrow length. The total period of irrigation is divided into equal intervals of advance time. Equation for calculating the factors by which the initial stream size should be multiplied to get inflow rates during subsequent time intervals has been developed. Graphs have been presented for simplifying the calculations. The method of practical application of the analysis is illustrated by an example.

70-71:04A-012
AUTOMATIC CUTBACK FURROW IRRIGATION SYSTEM DESIGN,
Nicolaescu, I., and Kruse, E. G.
Colorado State University, Fort Collins, Colorado.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, Proc. Paper 8358, p 343-353, 1971. 2 tab, 6 fig, 2 append, 7 ref.

Descriptors: *Furrow irrigation *Furrow systems, *Surface irrigation, Irrigation, Runoff, Streams.
Identifiers: Water application rate.

A field method for determining the size of a constantly decreasing furrow irrigation stream just adequate to prevent runoff after an initial stream has advanced the length of the furrow is described. This reduced stream can be approximated by several streams of constant flow, each applied for equal times. Use of the constant streams makes the irrigation system amenable to automatic methods of water application. Assuming that stream size is to be varied by regulating head-on spiles set in the walls of the irrigation lateral, procedures for determining spile size, variation in elevation of adjacent banks of spiles, and heads on the spiles for each discharge are presented. Equations are given for the number of furrows to be irrigated from each bay of the lateral with a given water supply. Methods for determining times of application and volumes of water supplied by the initial stream and each of the reduced streams are given. An example illustrates the application of all procedures and equations.

70-71:04A-013
MODEL FOR FARM IRRIGATION IN HUMID AREAS,
Windsor, J. S., and Chow, Ven Te.
Illinois University, Urbana, Illinois.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, Proc. Paper 8355, p 369-385, 1971. 2 tab, 4 fig, 2 append, 14 ref.

Descriptors: *Mathematical model, *Systems engineering, Agricultural engineering, Computers, Dynamic programming, Irrigation, Linear programming, Optimization, Operations research, Water resources.

A multicrop, multisoil, farm irrigation system is broken down into a number of discrete units, and then analyzed by means of a two-level optimization approach. At the first level of optimization dynamic programming is used to determine, on a per acre basis, the optimal irrigation policy, the maximum expected profit, and the expected monthly irrigation and labor and water requirements for each crop-soil combination and each level of irrigation development. At the next level of optimization linear programming is used to determine the irrigation system, the level of irrigation development, and the crop mix, which maximize the expected farm profit without violating any of the farm resource limitations. The model assumes that water supply is the important variable which controls plant growth, and uses a production function which is based on the concept of stress days. To show how the procedure may be set up on a computer, a hypothetical two-crop, two-soil, farm irrigation system is analyzed considering several resource combinations.

70-71:04A-014
SUBSURFACE IRRIGATION SYSTEM ANALYSIS AND DESIGN,
Fok, Yu-Si, and Willardson, L. S.
Hawaii University, Honolulu, Department of Civil Engineering.
American Society of Civil Engineers, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, p 449-454, 1971. 1 fig, 2 append, 5 ref.
(See 70-71:02G-058)

70-71:04A-015
IOWA PASSES EROSION-CONTROL LAW,
Moon, W. T.
Soil Conservation Service, Des Moines, Iowa.
Soil Conservation, Vol. 36, No. 12, p 272-273, 1971.
(See 70-71:02J-003)

70-71:04A-016
IRRIGATORS SHAPE THEIR LAND FOR WATER CONTROL,
Garner, B. J.
Soil Conservation Service, Harlingen, Texas.
Soil Conservation, Vol. 36, No. 7, p 149-150, 1971.
(See 70-71:03F-042)

70-71:04A-017
CENTER PIVOT IRRIGATION,
Heermann, D.
Colorado State University, Fort Collins, Dept of Agricultural Engineering.
World Irrigation; Vol. 20, No. 4, p 8-11, June 1970. 6 fig, 1 tab.

Descriptors: *Sprinkler irrigation, Uniformity coefficient, Irrigation systems, Arable land, Irrigation efficiency, Irrigation engineering, Crop production, Application methods.
Identifiers: *Center pivot, Sprinklers, Sprinkler design, Runoff, Irrigation research.

Self-propelled center pivot sprinkler irrigation systems have been and are currently being installed in the United States. All systems are similar in that a line of sprinklers rotate about a pivot point. Typically one line is designed to irrigate approximately 135 acres of a 160 acre field. There is considerable variation in design and drive mechanisms of the systems. Since they are continually moving, center pivot systems perform especially well in the wind. Many misconceptions about the design and operation of center pivot systems have developed and an attempt to correct these is made in this article. When properly designed, a center pivot system provides an efficient, automated irrigation system.

70-71:04A-018
LOSS OF STANDING WATER BY SEEPAGE HALTED WITH FLEXIBLE LINERS,
Irrigation Journal, Vol. 21, No. 4, p 14-15, July-August 1971. 3 fig.

Descriptors: *Canal lining, *Seepage losses, Plastics, Montana, Soil water, Irrigation canals, Waste water, Water control, Water loss.
Identifiers: *United States Bureau of Reclamation, Helena, Dillon.

The loss of water along two stretches of irrigation canal in the Helena and Dillon areas of Montana was tremendous. Freeze-thaw cycles during the cold season caused the concrete in the bottom of the canals to craze, crack, and pop up. Water losses in the area were calculated to be as high as 48 acre-feet per day over a 2 1/2 mile stretch of the canal. To rectify this condition, the U.S. Bureau of Reclamation called for bids to install flexible PVC vinyl membranes in the canals. The membranes were placed on the floor of the canal and up the 2:1 slopes and were covered with 16 inches of soil. The lining resulted in the canals being nearly water tight and will withstand the cold Montana winters.

70-71:04A-019
MOISTURE SENSOR PLACEMENT FOR REGULATION OF FURROW-IRRIGATION SYSTEMS.
Myers, R. G., and Edwards, D. M.
Valmont Industries, Valley, Nebraska.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 303-306, March 1970. 5 fig, 16 ref.

Descriptors: *Irrigation practices, *Automatic control, *Irrigation systems, Surface irrigation, Furrow irrigation.
Identifiers: *Soil moisture sensors, Intake rate, Water holding capacity.

A procedure has been developed for placing moisture-sensing devices in the soil profile to deactivate an automated furrow-irrigation system. Results of the study indicate that lateral sensor placement should be limited to the furrow centerline. A limitation of this nature makes it possible to determine sensor placement by having only to compute vertical sensor depth. Characteristics of surface flow along with the basic intake rate equation and the water holding capacity of the soil, provide a theoretical means for predicting vertical sensor depth.

70-71:04A-020
AUTOMATION OF SURFACE IRRIGATION WITH FLUIDIC DIVERTERS,
Kruse, E. G., Freeman, P. A., and Haise, H. R.
United States Department of Agriculture, Fort Collins, Colorado, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 357-361, March 1970. 11 fig, 6 ref.
(See 70-71:08A-002)

70-71:04A-021
FROST AND COLD PROTECTION BY SPRINKLERS: A NEW ASSESSMENT,
Gray, A. S.
Rain Bird Sprinkler Manufacturing Company, Glenora, California.
World Irrigation, Vol. 20, No. 2, p 12-13, March 1970. 1 fig.

Descriptors: *Irrigation practices, *Sprinkler irrigation, *Frost protection, Temperature control, Ice, Frost action, Orchards, Irrigation, Engineering.
Identifiers: Frost types, Frost damage.

Protecting crops with sprinkler irrigation is becoming more popular with growers who are learning the value of this type of protection. But if real results are to be obtained, a properly designed system, operated according to plan, will be the deciding factors. Design and operation guide lines were presented for the two types of frost common to cropping areas. Myths that sprinkler irrigation is an infallible crop protector are challenged.

70-71:04A-022
PRACTICALITY ESTABLISHED FOR TRAVELING SPRINKLER SYSTEMS,
Sisson, D. R.
L. R. Nelson Manufacturing Company, Incorporated, Illinois.
World Irrigation, Vol. 20, No. 2, p 15-16, March 1970. 1 fig, 2 tab.

Descriptors: *Sprinkler irrigation, *Irrigation practices, *Automation, Distribution systems, Crop production.
Identifiers: *Automatic irrigation, Traveling sprinkler systems.

The types of traveling sprinkler systems are listed and their advantages discussed. Test data is quoted and the practicality developed. An equation for application and uniformity is presented and discussed.

70-71:04A-023
PESTICIDES,
Metcalf, R. L.
Illinois University, Urbana, Illinois.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 57-60, March-April 1971. 1 fig, 2 tab, 12 ref.
(See 70-71:05B-030)

70-71:04A-024
ANIMAL WASTES,
Webber, L. R.
Guelph University, Guelph, Ontario.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 47-50, March-April 1971. 2 fig, 21 ref.
(See 70-71:05B-034)

70-71:04A-025
CONSERVATION OF SANDY SOILS WITH A SURFACE MULCH,
Fryrear, D. W., and Koshi, P. T.
United States Department of Agriculture, Big Springs, Texas, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3, p 492-495, March 1971. 10 fig, 10 ref.

Descriptors: *Soil conservation, *Water conservation, *Erosion control, *Mulching, Cultivation, Soil erosion, Sediment control, Runoff, Dust storms, Evaporation, Irrigation engineering.
Identifiers: *Pollution control.

A mulch surface cover on sandy soils will reduce wind erosion, increase soil moisture storage, improve dry aggregate stability, and increase crop yields. The percent soil surface covered with varying amounts of cotton gin trash, wheat, and sorghum stubble was determined. The percent soil cover was used to develop a mulch coefficient (100 percent soil cover equals a mulch coefficient of 1.0). The mulch coefficient was related to soil moisture storage, crop yield, evaporation, wind erosion loss, and runoff using the results of this study and previous research by other scientists. A mulch coefficient of 0.6 to 0.8 was sufficient to control wind erosion and runoff. Good soil moisture storage, evaporation reduction, and crop yields have been obtained with a mulch coefficient of 1.0.

70-71:04A-026
AUTOMATIC FURROW IRRIGATION SYSTEMS,
Humpherys, A. S.
United States Department of Agriculture, Kimberly, Idaho, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 1, p 466-470, January 1971. 7 fig, 2 tab, 18 ref.

Descriptors: *Irrigation practices, *Automation, Furrow irrigation, Irrigation engineering, Surface irrigation, Distribution systems, Irrigation design, Ditches.

One method for automating furrow irrigation systems is to place furrow tubes on grade in the ditch and then control the head, using time controlled check structures. An evaluation of two such systems showed that cutback stream flow was sensitive to head variations caused by varying supply flow and furrow inlet elevation errors. To minimize these variations, furrow tubes or inlet openings should be installed as close to design elevation as possible and the system operated at the design flow rate. Labor requirements can be reduced as much as 90 percent using semiautomated systems.

70-71:04A-027
WATER LOSSES DURING SPRINKLING,
Seginer, I.
Israel Institute of Technology, Haifa.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4, p 656-664, April 1971. 7 fig, 3 tab.

Descriptors: *Irrigation practices, *Sprinkler irrigation, *Evaporation, Distribution systems, Irrigation systems, Water loss, Meteorology.

An experiment was carried out in which water losses during sprinkling were determined for various meteorological and operation conditions. The regression lines of total loss on solar radiation, for the various operation conditions were practically parallel to each other, with slope of about 0.5. The minimum loss was for a treatment where the surface was wet but no drops were in the air. As the number of drops in the air increased and their size decreased, the total loss increased. From a theoretical analysis based on a simple resistance model it seems that spray evaporation was negligible relative to drift loss in this case.

70-71:04A-028
GRADED ROWS FOR THE CONTROL OF RILL EROSION,
Harris, W. S., and Watson, W. S., Jr.
Arkansas University, Fayetteville.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3, p 577-581, March 1971. 11 fig, 9 ref.

Descriptors: *Soil conservation, *Rill erosion, *Contour farming, *Erosion control, Soil erosion, Cultivation, Sediment control, Runoff, Flood control, Irrigation engineering.
Identifiers: *Pollution control, *Graded rows.

This paper is a report on graded rows that were designed, constructed, and farmed with the control of rill erosion as a primary objective. The research was on two separate and distinct land-grading problems. The first on a hill and the second on relatively steep bottom land. Graded rows are defined as bedded crop rows that channel the flow of surface water. The purpose of graded rows is to prevent surface water from concentrating on fields and causing erosion. Graded rows have eliminated rill erosion on hill land and permitted "controlled" rill erosion and sedimentation on bottom land.

70-71:04A-029
PREDICTION OF SEDIMENT YIELDS FROM SMALL WATERSHEDS,
Williams, J. R., Hiler, E. A., and Baird, R. W.
United States Department of Agriculture, Riesel, Texas.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 6,
p 1157-1162, June 1971. 5 fig, 5 tab, 19 ref.
(See 70-71:02E-009)

70-71:04A-030
PRESSURE DISTRIBUTION ON A CENTER-PIVOT SPRINKLER IRRIGATION SYSTEM,
Kincaid, D. C., and Heermann, D. F.
United States Department of Agriculture, Mitchell, Nebraska.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5,
p 556-558, May 1970. 3 fig, 5 tab, 5 ref.

Descriptors: *Irrigation practices, Sprinkler irrigation, Pipe flow, Fluid friction, Irrigation design, Head loss, Infiltration.
Identifiers: *Center pivot, *Pipe sizing.

Many center-pivot irrigation systems use 6-in. pipe. With the common 1,300-ft. system a pressure drop of 15-20 psi is found. This relatively high pressure loss causes higher than necessary pumping cost and improper pressure distribution on the sprinklers, thus causing the large sprinklers to operate at less than recommended pressures. Low pressures result in large drop sizes and reduction in soil intake rate. This analysis indicates that pipe sizes should be increased and pressure losses decreased to reduce pumping costs and provide a more uniform pressure distribution.

70-71:04A-031
CROP RESPONSE TO MIST IRRIGATION,
Howell, T. A., Hiler, E. A., and van Bavel, C. H. M.
Texas A & M University, College Station.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5,
p 906-910, May 1971. 8 fig, 3 tab, 17 ref.

Descriptors: *Irrigation practices, *Mist irrigation, *Lysimeters, Irrigation engineering, Plant growth, Application equipment, Irrigation systems, Sprinkler irrigation, Sprays.

An investigation of the response of southern peas to mist irrigation was conducted in a sheltered lysimeter installation in which complete control of the soil water balance could be maintained. Numerous crop, soil and meterological parameters were measured and evaluated to determine the growth response of the crop. Leaf water potential, measured by the pressure bomb method, increased in one trial by 3.4 bars after five minutes of misting. The leaf water potential was found to increase 3.9 bars on the average as a result of the mist application. Leaf temperature was reduced approximately 4.0 C on the average. Crop height and leaf area index exhibited a significant response to mist irrigation.

70-71:04A-032
THE INFERENCE OF INTAKE AND HYDRAULIC ROUGHNESS PARAMETERS FROM PLOT RUNOFF USING KINEMATIC WAVE THEORY,
Burman, R. D., and Black, R. D.
Wyoming University, Laramie.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 4,
p 479-481, April 1970. 5 fig, 3 tab, 5 ref.
(See 70-71:02E-012)

70-71:04A-033
LAND GRADING FOR IMPROVED SURFACE DRAINAGE,
Sewell, J. I.
Tennessee University, Knoxville.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 6,
p 817-819, June 1970. 2 fig, 4 tab, 4 ref.
(See 70-71:02E-013)

70-71:04A-034
SIMULATION VERSUS EXTREME VALUE ANALYSIS IN SPRINKLER SYSTEM DESIGN,
Stegman, E. C., and Shah, A. M.
North Dakota State University, Fargo.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3,
p 486-491, March 1971. 5 fig, 7 tab, 8 ref.

Descriptors: *Irrigation practices, *Sprinkler irrigation, Design, Irrigation engineering, Climatic data, Computer models.
Identifiers: *Extreme value theory, *Peak use rate.

Climatic data of 37 years for Oakes, North Dakota, were analyzed according to Gumbel extreme value theory. The extreme value distributions of these parameters were then used to estimate probabilities of inadequacy to be expected for design-peak use rates of varying magnitudes. A water-balance model was designed to simulate the operation of specific sprinkler-system types. The model was applied to the selected 37-year period, thus, identical sets of ET data were utilized in both analyses. The simulated rates were then compared with the peak use pumping rates. It appears that extreme-value distributions of either ET or net evaporation rates will provide conservative estimates of design peak use rates in subhumid and humid areas.

70-71:04A-035
SEASONAL VARIATION OF HYDRAULIC PARAMETERS AND THEIR INFLUENCE UPON SURFACE IRRIGATION APPLICATION EFFICIENCY,
Linderman, C. L., and Stegman, E. C.
United States Department of Agriculture, Lincoln, Nebraska, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5,
p 914-923, May 1971. 10 fig, 4 tab, 11 ref.

Descriptors: *Irrigation practices, *Fluid mechanics, *Open channels, Open channel flow, Roughness (hydraulic).
Identifiers: *Furrow design, Furrow flow.

This study was conducted in two parts: (a) A field investigation was made to observe and characterize the seasonal hydraulic behavior of a farm-size irrigated unit, and (b) an analysis was made of the relative influence of several parameters on water application efficiency. Physical factors observed in the field included infiltration rate and retardance coefficient variations with irrigations and season. Small grains and alfalfa were irrigated by graded borders and potatoes by graded furrows. The hydraulic behavior of the system was mainly influenced by a decreasing infiltration rate with successive irrigations. Large increases in required infiltration opportunity time occurred from the first to second irrigation in each crop. These increases diminished with successive irrigations and approached near constant values at about the fourth irrigation.

70-71:04A-036
SILT TRANSPORT BY THIN FILM FLOW,
Podmore, T. H., and Merva, G. E.
Queensland Institute of Technology, Toowoomba, Australia.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 6,

p 1065-1072, June 1971. 6 fig, 2 tab, 15 ref.
(See 70-71:02E-014)

70-71:04A-037
THE EFFECT OF INTAKE EQUATIONS ON THE DEVELOPMENT OF THE WATER ADVANCE EQUATIONS FOR SURFACE IRRIGATION,
Fok, Y. S., Bishop, A. A., and Shih, C. C.
Hawaii University, Honolulu.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 5,
p 801-805, May 1971. 2 fig, 1 tab, 9 ref.

Descriptors: *Irrigation practices, *Surface irrigation, *Infiltration, Border irrigation.
Identifiers: *Advance rate.

The functional effects of the intake equations on the water advance equations for surface irrigation have been examined by a comparison of the computed results of experimental data from five border irrigation trials conducted at Logan, Utah. Although the variation of intake rate at different locations in the trial borders are within a fairly narrow range, it may offset the small functional difference between the two intake rate equations which were used to develop the water advance equations for surface irrigation. Additional experiments should be conducted on soils having definite functional intake rate characteristics. The ability of both water advance equations to yield good computational results are presented.

70-71:04A-038
ELECTRIC CONTROLS FOR AUTOMATIC SURFACE IRRIGATION SYSTEMS WITH REUSE SYSTEM,
Fischbach, P. E., Thompson, T. L., and Stetson, L. E.
Nebraska University, Lincoln.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3,
p 286-288, March 1970. 10 fig, 3 ref.

Descriptors: *Irrigation practices, *Irrigation systems, *Automation, Electrical equipment, Water conservation.
Identifiers: Electric controls, Reuse system.

The equipment and controls needed for an automatic surface irrigation system, including reuse of the runoff water is described. The system described was installed in 1966 and had been operating for three years. In designing the system the following points should be kept in mind. The electric controls should be simple, reliable, and provide protection for the electric motors and irrigation equipment. They should include controls to start the system, time the irrigation, change the water from one set to another, recycle the runoff water, and shut the system off. Schematic drawings of each part of the system are presented and discussed. The use and care of the system is also considered.

70-71:04A-039
THE HYDRAULICS OF AN AUTOMATED FURROW IRRIGATION SYSTEM WITH RECTANGULAR SIDE WEIR OUTLETS,
Sweeten, J. M., and Garton, J. E.
Oklahoma State University, Stillwater.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 6,
p 746-751, June 1970. 12 fig, 1 tab, 17 ref.

Descriptors: *Irrigation practices, *Application methods, *Automation, Furrow irrigation, Border irrigation, Irrigation systems, Application equipment, Irrigation engineering.
Identifiers: Side weirs.

A side weir irrigation system consists of weirs installed in the side of an irrigation channel to measure and control the discharge to each individual area. The advantages of this type of system over most existing systems include: self priming discharge, simplicity of construction, precise metering of discharge, adaptability into automated systems, lower operating heads. Hydraulic experiments were designed and conducted to obtain information which could be used in the design of automatic surface irrigation systems using side weirs. The findings are reported. The side weirs proved to be satisfactory and provided accurate measurements of water applied.

70-71:04A-040
SALINITY AND THE HYDROLOGIC CYCLE,
Holmes, J. W.
Flinders University, South Australia. School of Physical Sciences.
Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971. Canberra, Australia, p 25-40. 6 fig, 8 tab, 21 ref.
(See 70-71:02A-004)

70-71:04A-041
SCHEDULING FURROW IRRIGATION FOR PRACTICAL FARM OPERATIONS,
Woodward, G.
United States Soil Conservation Service, Lincoln, Nebraska.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4, p 731-733, April 1971. 2 fig, 1 tab.

Descriptors: *Irrigation practices, *Furrow irrigation, Farm management, Infiltration, Irrigation design, Irrigation systems, Irrigation engineering.
Identifiers: Cuttback methods.

The large labor requirements necessary to operate a cutback furrow irrigation system is shown. It was found that the complexity and continual change in the schedule caused irrigators to abandon the method completely and adopt a schedule that fit in with their other farm work. Thus, the benefits of the cutback system were completely lost. Several modifications to the system are suggested and the equations necessary to calculate stream size and length of run were presented. With this method, it is possible to set up the system to be changed on even hours and the schedule repeats each day. The method is greatly simplified and more acceptable to irrigators.

70-71:04A-042
SIMULATION OF EXPECTED CROP RETURNS,
Sowell, R. S., Liang, T., and Link, D. A.
North Carolina State University, Raleigh.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 2, p 383-386, February 1971. 9 fig, 1 tab, 8 ref.

Descriptors: *Mathematical models, *Crop growth, *Farm management.
Identifiers: Farm operation, Machinery use.

Models of plant growth and the effects of farming operations are presented. These can be used to maximize the efforts of farm work. The use of farm machinery and farm operations on production are considered. Two models were developed; namely, a probabalistic and a simulation model. These are believed to be valuable tools in making farm management decisions. The models could be of great value in helping a farmer plan his year's operation. Theoretically, the two models are usually applicable to all situations, however, it was found that each model was more applicable to various situations.

70-71:04A-043
A PROCESS MODEL FOR COMPUTER CONTROL OF CROP GROWTH,
Smith, M. R.

Hawaii University, Honolulu.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3, p 475-479, March 1971. 6 fig, 2 tab, 7 ref.

Descriptors: *Mathematical models, *Crop growth, Farm management.

A study into computer simulation of crop growth was conducted. A model of crop growth was developed and tested. By using the computer to schedule farming operations it is felt that efforts could be maximized and production increased. Tests were conducted of plant growth control using growth chambers. Test data was collected over a large range of the pertinent variables which included: air temperature, leaf temperature, humidity, CO2 concentration, and radiation. Good results were obtained for predicting crop growth.

70-71:04A-044
THE APPROPRIATE GRADE OF A GATED PIPE,
Chu, S. T., and Moe, D. L.
South Dakota State University, Brookings.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4, p 727-733, April 1971. 1 fig, 2 tab, 5 ref.

Descriptors: *Hydraulics, *Hydraulic gradient, *Irrigation systems, *Pipe flow, Irrigation engineering, Head loss.
Identifiers: *Gated pipe.

The general solution of the hydraulic grade line of a lateral with uniform outflow from equally spaced outlets is obtained. A numerical table of approximate formula are presented to facilitate the determination of the hydraulic gradient of a gated pipe system. Several qualifications and findings are listed.

70-71:04A-045
EFFICIENCIES OF AN AUTOMATED SURFACE IRRIGATION SYSTEM WITH AND WITHOUT A RUNOFF RE-USE SYSTEM,
Fischbach, P. E., and Somerhalder, B. R.
Nebraska University, Lincoln.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4, p 717-719, April 1971. 4 fig, 2 tab, 8 ref.

Descriptors: *Irrigation practices, *Irrigation systems, *Furrow irrigation, *Automation, Irrigation design, Irrigation engineering, Irrigation efficiency.
Identifiers: Re-use system.

A furrow irrigation system with a pump back re-use system was tested. The coefficient of uniformity was found to be 91.8. The water application efficiency varied from 56.5 to 73 percent without the re-use system; while the efficiency with the re-use system varied from 84.4 to 96.8. The row spacings were 30 in. with a run length of 1100 ft. The irrigation time was controlled automatically at 2 hrs. and 15 min. It was concluded that: (1) An automatic surface irrigation system with a re-use system is very efficient. The re-use system eliminated the labor needed to use a cut-back furrow stream. (2) Uniform water application can be accomplished using a furrow stream of three times the basic intake rate.

70-71:04A-046
EFFECT OF VEGETAL LENGTH AND SPATIALLY VARIED FLOW ON VELOCITY DISTRIBUTION COEFFICIENTS,
McCool, D. K.
United States Department of Agriculture, Stillwater, Oklahoma.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5, p 603-607, May 1970. 9 fig, 4 tab, 14 ref.
(See 70-71:08A-003)

70-71:04A-047
SQUARE-MATIC LATERALLY . . . NEW CONCEPT IN SPRINKLER IRRIGATION ACHIEVES GOALS LONG SOUGHT BY FARMERS,
R. M. Wade and Company, Portland, Oregon.
Irrigation Journal, Vol. 21, No. 2, p 10-11, March-April 1971. 1 fig.

Descriptors: *Sprinkler irrigation, *Irrigation practices, *Automation, Distribution systems, Crop production.
Identifiers: *Automatic irrigation, Continuous-move systems.

An entirely new concept in sprinkler irrigation has been announced by R. M. Wade & Company, manufacturer of Wade Rain. The new system, called "Square-Matic", is a continuously moving lateral irrigation line which automatically irrigates square or rectangular fields. The system consists of 660 ft. of 5 inch rubber hose, 1/4 mile of aluminum line supported by 16 individually controlled drive towers and a winch cart. Travelling 1320 feet in 12 to 48 hours, depending on crop needs, the system can apply 1/2 to 2 inches of water uniformly to a 40 acre tract. Advantages of the system include; no wasted land in the corners, uniform, low application rates, and no increase in application rate from one end of the line to the other.

70-71:04A-048
GRAIN SORGHUM RESPONSE TO NUMBER, TIMING, AND SIZE OF IRRIGATIONS IN THE SOUTHERN HIGH PLAINS,
Musick, J. T., and Dusek, D. A.
United States Department of Agriculture, Bushland, Texas.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3, p 401-404, March 1971. 2 fig, 2 tab, 11 ref.
(See 70-71:03F-068)

70-71:04A-049
SYSTEMS APPROACH TO DESIGN OF SPRINKLER IRRIGATION,
Liang, T., and Wu, I. P.
Hawaii University, Honolulu.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5, p 618-621, May 1970. 11 fig, 19 ref.
(See 70-71:03F-067)

SECTION XVII

WATER QUANTITY MANAGEMENT AND CONTROL

GROUNDWATER MANAGEMENT (Group 04B)

70-71:04B-001
A MEAN VALUE THEOREM IN PORE PRESSURE EVALUATION BY THE METHOD OF IMAGES,
Ransford, G. D.
McGill University, Montreal (Quebec).
Water Resources Research, Vol. 6, No 2, p 645-648, April 1970. 4 p, 2 ref.

Descriptors: *Groundwater movement, *Pore pressure, Equations, Drainage, Permeability, Laplaces equation, Porous media.
Identifiers: Method of images.

It is shown that mean pore pressure measured transversally through a rectangular domain in which groundwater flow is taking place from front to rear varies linearly from one sink (or source) to another provided such sinks or sources are located on the centerline of the domain, midway between the side faces. Methods of computation of the mean pore pressure at any section are given. The specific application is to uplift evaluation in concrete dams, but the theorem applies to any problem governed by the Laplace theorem.

70-71:04B-002
TESTS IN UNCONFINED ANISOTROPIC AQUIFERS,
Boulton, N. S., and Pontin, J. M. A.
Sheffield University, (England). Dept of Civil Engineering.
Journal of Hydrology, Vol. 14, No. 1, p 53-65, October 1971. 2 fig, 6 ref.
3 append.

Descriptors: *Drawdown, *Water yield, *Unsteady flow, *Theis equation, Aquifer characteristics, Water levels, Aquifers, Withdrawal, Permeability, Storage coefficient, Specific yield, Transmissivity.
Identifiers: *Pumping tests, *Aquifer tests.

An equation derived for the drawdown of the water-table under non-equilibrium conditions allows for uniform anistropy and delayed yield from storage. The allowance for delayed yield involves four parameters. The pumped well and observation wells may penetrate the aquifer to any depth. The theory assumes that the aquifer and water are incompressible and that the drawdown of the water-table is small. Using time-drawdown recordings from a pumping test at a constant rate of discharge, a theoretical curve is closely matched to the field curve by determining suitable values of the parameters.

70-71:04B-003
MODERN TECHNIQUES IN GROUND-WATER STUDIES,
Williams, Dennis E.
Dept of Water and Power, Los Angeles, California
Journal American Water Works Association, Vol. 63, No. 7, p 433-438, July 1971.
6 p, 9 fig, 1 tab, 4 ref.

Descriptors: *Groundwater, *Management, *Transmissivity, *Storage, *Aquifers, Reservoirs, Wells, Casings, Pumping, Mathematical models, Simulation analysis, Digital computers, Optimization, Planning.

A testing procedure for ascertaining the transmissivity and storage characteristics of ground-water reservoirs and a mathematical model for predicting future developments were outlined. The step-draw-down test provided a convenient guide for well-redevelopment work by estimating the present conditions of the well casing. Regional aquifer response due to the interface of well fields was analyzed by the principal of superposition. Data from

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pumping tests provided insight into formation characteristics and controlled the design of wells and pumps, the spacing between wells, and the amount of water that safely could be withdrawn from, or added to, aquifer storage during any given time period. One useful tool in acquiring knowledge of reservoir behavior under various pumping and recharge regimens was a digital simulation model. This model mathematically blended the geologic and hydrologic properties of the reservoir and solved specific recharge-discharge requirements imposed on the area by use of a digital computer. These predictive models were used to manage ground-water resources by quantity and quality simulation in such a manner as to optimize the water needs, both for export and local use.

70-71:04B-004
NOTES: HALF-MINUTE COUNTS FOR NEUTRON PROBES,
Rogerson, T. L.
United States Department of Agriculture Forest Service, Harrison, Arkansas.
Soil Science, Vol. 110, No. 5, p 359-360, November 1970. 2 tab, 4 ref.
(See 70-71:02E-005)

70-71:04B-005
AIR PUMP FOR SMALL-DIAMETER PIEZOMETERS,
Trescott, P. C., and Pinder, G. F.
Nova Scotia Department of Mines, Halifax, Nova Scotia.
Groundwater Hydrology, Vol. 8, No. 3, p 10-15, May-June 1970. 8 fig, 5 ref.
(See 70-71:02F-035)

70-71:04B-006
LOSS OF STANDING WATER BY SEEPAGE HALTED WITH FLEXIBLE LINERS,
Irrigation Journal, Vol. 21, No. 4, p 14-15, July-August 1971. 3 fig.
(See 70-71:04A-018)

70-71:04B-007
SUMMARY OF PANEL ON CARBON ISOTOPES IN SUBSURFACE HYDROLOGY AND THE ROLE OF PALEOCLIMATES IN THEIR INTERPRETATION,
Bradley, E., Scientific Secretary
Journal of Hydrology, Vol. 11, No. 4, p 439-441, April 1970.
(See 70-71:02F-036)

70-71:04B-008
STARTING WITH TRICKLE IRRIGATION,
DeRemer, E. D.
Business Dynamics Corporation, Phoenix, Arizona.
Reclamation Era, Vol. 56, No. 4, p 15-17, November 1970.
(See 70-71:03C-009)

70-71:04B-009
ISOTOPIC EXCHANGE STUDIES OF MICRONUTRIENTS IN SOILS,
Lopez, P. L., and Graham, E. R.
Missouri University, Columbia.
Soil Science, Vol. 110, No. 1, p 24-30, July, 1970. 4 tab, 16 ref.
(See 70-71:02K-025)

70-71:04B-010
THE CHEMICAL HISTORY OF SOME SPRING WATERS IN CARBONATE ROCKS,
Jacobson, R. L., and Langmuir, D.
Pennsylvania State University, University Park, Dept of Geochemistry and Mineralogy.
Groundwater Hydrology, Vol. 8, No. 3, p 5-9, May-June 1970. 4 fig, 2 tab, 9 ref.
(See 70-71:02F-039)

70-71:04B-011
CALCULATION OF ELECTRICAL CONDUCTIVITY FROM SOLUTION COMPOSITION DATA AS AN AID TO IN-SITU ESTIMATION OF SOIL SALINITY,
McNeal, B. L., Oster, J. D., and Hatcher, J. T.
United States Department of Agriculture, Riverside, California, Agricultural Research Service, Soil and Water Conservation Research Division, United States Salinity Laboratory.
Soil Science, Vol. 110, No. 6, p 405-414, December 1970. 2 fig, 6 tab, 12 ref.
(See 70-71:02K-026)

70-71:04B-012
DETERMINATION OF A WATER TABLE IN A SOIL PROFILE USING THE PLATINUM OXYGEN CATHODE,
West, D. W., and Black, J. D. F.
Horticulture Department of Agriculture, Ferntree Gully, Victoria, Australia.
Soil Science, Vol. 110, No. 2, p 119-123, August 1970. 3 fig, 1 tab, 8 ref.
(See 70-71:02F-040)

70-71:04B-013
SOIL HYDRAULIC CONDUCTIVITY AND BULK VOLUME CHANGES DURING CYCLIC CALCIUM-SODIUM EXCHANGE,
Waldron, L. J., and Constantin, G. K.
California University, Berkeley.
Soil Science, Vol. 110, No. 2, p 81-85, August 1970. 3 fig, 3 tab, 7 ref.
(See 70-71:02K-027)

70-71:04B-014
THE EFFECT OF ELECTROLYTE COMPOSITION ON HYDRAULIC CONDUCTIVITY OF CERTAIN TEXAS SOILS,
Naghshineh-Pour, B., Kunze, G. W., and Carson, C. D.
Ahwaz Agricultural College, Ahwaz, Iran.
Soil Science, Vol. 110, No. 2, p 124-127, August 1970. 5 fig, 1 tab, 13 ref.
(See 70-71:02K-028)

70-71:04B-015
THE EFFECT OF THE ENTRAPPED AIR ON THE HYSTERESIS CURVES OF A POROUS BODY AND ON ITS HYDRAULIC CONDUCTIVITY,
Poulovassilis, A.
Agricultural Research Council, Cambridge, England, Soil Physics.
Soil Science, Vol. 109, No. 3, p 154-162, March 1970. 8 fig, 3 ref.
(See 70-71:02G-064)

70-71:04B-016
THE CONCENTRATION OF K, Ca, AND Mg IN THE SATURATION EXTRACT IN RELATION TO EXCHANGEABLE K, Ca, AND Mg,
Nemeth, K., Mengel, K., and Grimme, H.

Landwirtschaftliche Forschungsanstalt, Buntehof, Hannover.
Soil Science, Vol. 109, No. 3, p 179-185, March 1970. 5 fig, 1 tab, 15 ref.
(See 70-71:02K-029)

70-71:04B-017
ANION EXCLUSION EFFECTS ON CHLORIDE MOVEMENT IN SOILS,
Thomas, G. W., and Swoboda, A. B.
Kentucky University, Lexington; and Texas A & M University, College Station.
Soil Science, Vol. 110, No. 3, p 163-166, September 1970. 5 fig, 1 tab, 9 ref.
(See 70-71:02K-030)

70-71:04B-018
DISSOLUTION OF DICALCIUM PHOSPHATE IN RELATION TO IRON OXIDE CONTENT OF ACID SOILS,
Sree Ramulu, U. S., and Pratt, P. F.
Agricultural College, Coimbatore, Madras, India.
Soil Science, Vol. 109, No. 1, p 35-39, January 1970. 2 fig, 2 tab, 15 ref.
(See 70-71:02K-031)

70-71:04B-019
INFLUENCE OF VARIOUS TREATMENTS ON THE DISSOLUTION OF DICALCIUM PHOSPHATE IN SOILS,
Sree Ramulu, U. S., and Pratt, P. F.
California University, Riverside, Dept of Soils and Plant Nutrition.
Soil Science, Vol. 109, No. 3, p 186-189, March 1970. 2 tab, 16 ref.
(See 70-71:02K-032)

70-71:04B-020
TRICKLE IRRIGATION. . . A MORE EFFICIENT MEANS OF WATER MANAGEMENT,
Lyons, C. G., Jr.
Texas Agricultural Extension Service, Welasco, Texas.
Texas Agricultural Progress, Vol. 18, No. 1, p 3-4, Winter, 1972. 5 fig.
(See 70-71:03C-010)

70-71:04B-021
CALIFORNIA DRIP-IRRIGATION TESTS MAY PROVE METHOD SIGNIFICANT,
Irrigation Journal.
Irrigation Journal, Vol. 21, No. 2, p 12-13, March-April 1971.
(See 70-71:03C-011)

70-71:04B-022
NEW FINDINGS ON THE USE OF TRICKLE IRRIGATION SYSTEMS IN THE UNITED STATES, AUSTRALIA & ISRAEL,
DeRemer, E. D.
Business Dynamics Corporation.
World Irrigation, Vol. 20, No. 6, p 14-16, December 1970. 4 fig, 1 tab.
(See 70-71:03C-012)

70-71:04B-023
COMPUTER SIMULATION OF TILE SYSTEMS,
Bird, N. A., and McCorquodale, J. A.
Ontario Department of Agriculture and Food, Stratford, Canada, and Windsor

University, Windsor, Canada, Dept of Civil Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 1,
p 175-178, January 1971. 7 fig, 8 ref.
(See 70-71:02G-074)

70-71:04B-024
CONTROL OF SOIL MOISTURE DURING SPRINKLER IRRIGATION,
Keller, J.
Utah State University, Logan, Agricultural and Irrigation Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 6,
p 885-890, June 1970. 6 fig, 2 tab, 18 ref.
(See 70-71:02G-075)

70-71:04B-025
UNLINED MOLE LINES FOR IRRIGATION,
Norum, D. I., and Gray, D. M.
Saskatchewan University, Saskatoon, Canada.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5,
p 661-668, May 1970. 3 fig, 1 tab, 11 ref.
(See 70-71:02G-079)

70-71:04B-026
DITCH DRAINAGE OF ANISOTROPIC NONHOMOGENEOUS POROUS MEDIA: A MODEL STUDY,
Rochester, E. W., Jr., and Kriz, G. J.
Auburn University, Auburn, Alabama, Dept of Agricultural Engineering.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5,
p 626-628, May 1970. 8 fig, 2 ref.
(See 70-71:02F-053)

70-71:04B-027
HYDRAULIC CONDUCTIVITY SAMPLING FOR CONFIDENCE,
Dylla, A. S., and Guitjens, J. C.
United States Department of Agriculture, Reno, Nevada, Agricultural Research Service, Nevada Agricultural Experiment Station.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 4,
p 485-488, April 1970. 4 fig, 2 tab, 6 ref.
(See 70-71:02F-054)

70-71:04B-028
EVAPOTRANSPIRATION AND DRAINAGE FROM THE ROOT ZONE OF IRRIGATED COASTAL BERMUDAGRASS ON COASTAL PLAINS SOILS,
Doss, B. D., and Taylor, H. M.
United States Department of Agriculture, Thorsby, Alabama.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 4,
p 426-429, April 1970. 5 fig, 4 tab, 10 ref.
(See 70-71:03F-057)

70-71:04B-029
A DIGITAL SIMULATION OF THE DYNAMIC SOIL MOISTURE STATUS,
Jones, J. W., and Verma, B. P.
Mississippi State University, State College, United States Department of Agriculture, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4,
p 660-664, April 1971. 6 fig, 8 ref.
(See 70-71:02G-081)

70-71:04B-030
A COMPARISON OF METHODS FOR THE DETERMINATION OF SOIL ORGANIC PHOSPHOROUS,
Williams, J. D. H., Syers, J. K., Walker, T. W., and Rex, R. W.
Lincoln College, Canterbury, New Zealand, Dept of Soil Science; and California University, Riverside, Dept of Geological Sciences.
Soil Science, Vol. 110, No. 1, p 13-17, July 1970. 1 fig, 2 tab, 9 ref.
(See 70-71:02K-034)

70-71:04B-031
MOVEMENT OF SALT AND WATER NEAR CRYSTALLINE SALT IN RELATIVELY DRY SOIL,
Scotter, D. R., Raats, P. A. C.
Wisconsin University, Madison.
Soil Science, Vol. 109, No. 3, p 170-178, March 1970. 9 fig, 17 ref.
(See 70-71:02K-035)

70-71:04B-032
FIELD MEASUREMENT OF HYDRAULIC CONDUCTIVITY ABOVE A WATER TABLE WITH AIR-ENTRY PERMEAMETER,
Aldabagh, A. S. Y., and Beer, C. E.
Iowa State University, Ames, Agricultural Engineering Department.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 1, p 29-31, January 1971. 3 tab, 12 ref.
(See 70-71:02F-058)

70-71:04B-033
THE GEOCHEMISTRY OF UNDERGROUND WATER,
Swaine, D. J., and Schneider, J. L.
Division of Mineralogy, Sydney, Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971. Canberra, Australia, p 3-23. 7 fig, 2 tab, 45 ref.
(See 70-71:02F-060)

70-71:04B-034
TRANSPORT OF SALTS IN UNSATURATED AND SATURATED SOILS,
Peck, A. J.
Division of Soils, Wembley, Western Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 109-123. 1 fig, 67 ref.
(See 70-71:02F-061)

70-71:04B-035
GROUNDWATER PROBLEMS OF THE INTERACTION OF SALINE AND FRESH WATER,
Wooding, R. A.
Commonwealth Scientific and Industrial Research Organization, Canberra, Australia, Division of Environmental Mechanics.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 125-139. 55 ref.
(See 70-71:01B-004)

70-71:04B-036
PREDICTING IRRIGATIONS FROM CLIMATIC DATA AND SOIL PARAMETERS,
Franzoy, C. E., and Tankersley, E. L.
Salt River Project, Phoenix, Arizona.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 6,

p 814-816, June 1970. 4 fig, 4 ref.
(See 70-71:02G-090)

SECTION XVIII

WATER QUANTITY MANAGEMENT AND CONTROL

EFFECTS ON WATER OF MAN'S NON-WATER ACTIVITIES (Group 04C)

70-71:04C-001
INFLUENCE OF LAND USE ON RUNOFF FROM AGRICULTURAL WATERSHEDS,
Ricca, V. T., Simmons, P. W., McGuinness, J. L., and Taiganides, Paul E.
Ohio State University, Columbus.
American Society Agricultural Engineers Transactions, Vol. 13, No. 2, p 187-190, March-April 1970. 4 p, 3 fig, 5 tab, 6 ref.

Descriptors: *Watershed management, *Land use, *Runoff, *Agriculture, Streamflow, Rainfall, Reforestation, Groundwater, Water table, Percolation, Hydrology, Hydrologic data.
Identifiers: North Appalachian Experimental Watershed (Ohio).

Thirty years of runoff data from agricultural watersheds at the North Appalachian Experimental Watershed were analyzed to determine the effects of land use on streamflow. Reforestation and improved cropping reduced annual and seasonal streamflow. High flows were reduced in both seasons, but the treatment effects on low flows were not consistent. A decrease in percolation potential was indicated by the declining trend of the November 1 groundwater level. The time trend of flow changed from strongly negative in the first 10 years to insignificant in the last 10 years of record, indicition that the major effects of land use and treatment on streamflow have been reached. Hydrologically, the treated watersheds have stabilized in their new flow regimes.

70-71:04C-002
VARIOUS ESTIMATES OF THE EFFECT OF AGRICULTURE ON RUNOFF,
Koronkevich, N. I.
Akademiya Nauk SSSR, Moscow. Institute Geografii.
Soviet Hydrology: Selected Papers, No. 1, p 21-29, 1970. 5 fig, 5 tab, 15 ref.
Translated from Izvestiya Akad Nauk SSSR, Ser Geog, No. 1, p 49-58, 1970.

Descriptors: *Rainfall-runoff relationships, *Land use, *Water balance, Water utilization, Consumptive use, Evapotranspiration, Soil-water-plant relationships.
Identifiers: USSR.

Experimental data are used to estimate the effect of autumn plowing on slope runoff for individual natural zones of the USSR. Two versions of the water-balance method of computing the transformations of slope and river runoff were compared. One method uses average data for the entire observation record of runoff stations, and the other takes into account the wetness of individual years and periods. The present reduction in the long-period average Don River runoff at the Georgiu-Dezh gaging station, as compared with the period prior to 1950, is estimated at 9% by the first method and 8% by the second. The decrease is 5% in wet years and 10-11% in medium wet and dry years.

70-71:04C-003
MODELING THE EFFECT OF LAND USE MODIFICATIONS ON RUNOFF,
Onstad, C. A., and Jamieson, D. G.
Agricultural Research Service, Brookings, South Dakota; and Water Resources Board, Reading (England).
Water Resources Research, Vol. 6, No. 5, p 1287-1295, October 1970. 9 p, 9 fig, 8 tab, 6 ref.

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Descriptors: *Rainfall-runoff relationships, *Mathematical models, *Precipitation excess, *Parametric hydrology, Simulation analysis, Routing, Synthetic hydrology, Runoff forecasting, Land use, Land management, Hydrograph analysis, Optimization, Flood control, Soil conservation.
Identifiers: *Runoff management.

The natural apportionment of rainfall excess to surface and subsurface flow can mean the difference between large flow rates for a short time or more manageable flow rates over a longer time. By using available soil storage, peak flood flows can be reduced without necessarily reducing the total volume of runoff. A model was made to simulate this phenomenon. The land phase of the hydrologic system was simulated by a series of interconnected, nonlinear reservoirs and the channel phase by a single linear reservoir. By manipulation of parameters, which mathematically represent physical measurements, the watershed response to the addition of conservation practices, such as terracing, may be predicted.

70-71:04C-004
LOSS OF STANDING WATER BY SEEPAGE HALTED WITH FLEXIBLE LINERS,
Irrigation Journal, Vol. 21, No. 4, p 14-15, July-August 1971. 3 fig.
(See 70-71:04A-018)

SECTION XIX

WATER QUANTITY MANAGEMENT AND CONTROL

WATERSHED PROTECTION (Group 04D)

70-71:04D-001

SEDIMENT YIELD REDUCTIONS ON WATERSHEDS TREATED WITH FLOOD-RETARDING STRUCTURES,

Allen, P. B., and Welch, N. W.
Agricultural Research Service, Chickasha, Oklahoma, Soil and Water Conservation Research Division
Transactions of the American Society of Agricultural Engineers, Vol. 14, No. 5, p 814-817, 1971. 12 fig, 2 tab, 4 ref.

Descriptors: *Sediment yield, *Detention reservoirs, Sediment transport, Sediments, Sedimentation, Sedimentation rates, Sediment discharge, Sediment load, Sedimentology, Agricultural watersheds, *Deposition (Sediments), Erosion, Alluvial channels, Channel erosion, Soil erosion, Soil conservation, Project benefits, Turbidity, Mass curves, *Erosion control.
Identifiers: *Sediment reduction, Sediment transport curves, *Watersned treatment.

Sediment yields dropped sharply on four watersheds after flood-retarding reservoirs were installed. Drainage areas for the watersheds range from 0.88 to 206 square miles. The largest change was on a 33-square-mile watershed where sediment yield decreased 60 percent. Much of this reduction was attributed to decreased channel erosion resulting from regulated flows through the reservoir network. Although reservoirs substantially decreased sediment yields at the Sugar Creek gaging station, no change in yield could be detected on the Washita River. The small-capacity, sand-filled Sugar Creek channel caused deposition of the sediment before it could reach the river. Later dredging of the channel greatly increased the sediment delivered to the Washita River.

70-71:04D-002

CONTROL OF SEDIMENT FLOW INTO SUBSURFACE DRAINS,

Gulati, Om P., Schwab, Glenn O., and Reeve, Ronald C.
Ohio Agricultural Research and Development Center, Columbus; and Agricultural Research Service, Columbus, Ohio. Soil and Water Conservation Research Division.
ASCE Proceedings, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR 4, p 437-449, December 1970. 13 p, 10 fig, 1 tab, 8 ref, append.

Descriptors: *Subsurface drains, *Tile drains, *Sediment control, Velocity, Sediment transport, Sedimentation, Silting, Filters, Sands, Analog models, Hydraulic models.
Identifiers: Drain sedimentation.

Sediment inflow into subsurface drains in noncohesive soils may be alleviated by using an impervious cover over a drain having inflow openings only at the top. Water flows between the cover and the outer drain surface in an upward direction before entering the openings at the top of the drain. Sediment inflow is prevented if the flow velocity is less than the critical boiling velocity. In this paper the shape of the upflow channel openings and the velocity distribution across the openings are evaluated. Terzaghi's concept of effective stress is the basis for the theoretical velocity distribution. An electric analog model was employed to verify this theory. A laboratory model was used to determine critical velocities. Critical boiling velocities for fine sand and glass beads are about 1% of Stoke's settling velocity. Within reasonable limits the upflow channel width and shape can be designed to prevent movement of sediment. High water tables have the greatest influence on velocity.

70-71:04D-003
IOWA PASSES EROSION-CONTROL LAW,
Moon, W. T.
Soil Conservation Service, Des Moines, Iowa.
Soil Conservation, Vol. 36, No. 12, p 272-273, 1971.
(See 70-71:02J-003)

70-71:04D-004
SEDIMENT,
Robinson, A. R.
United States Department of Agriculture, Oxford, Mississippi, Sedimentation Laboratory.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 61-62, March-April 1971. 8 ref.
(See 70-71:05B-031)

70-71:04D-005
A PRIMER ON AGRICULTURAL POLLUTION,
Wadleigh, C. H.
United States Department of Agriculture, Beltsville, Maryland, Agricultural Research Service, Office of the Administrator.
In: Journal of Soil and Water Conservation, A Primer on Agricultural Pollution, Individual Papers, Vol. 26, No. 2, p 44-65, March-April 1971.
(See 70-71:05B-033)

70-71:04D-006
CONSERVATION OF SANDY SOILS WITH A SURFACE MULCH,
Fryrear, D. W., and Koshi, P. T.
United States Department of Agriculture, Big Springs, Texas, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3, p 492-495, March 1971. 10 fig, 10 ref.
(See 70-71:04A-025)

70-71:04D-007
GRADED ROWS FOR THE CONTROL OF RILL EROSION,
Harris, W. S., and W[illegible]son, W. S., Jr.
Arkansas University, Fayetteville.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3, p 577-581, March 1971. 11 fig, 9 ref.
(See 70-71:04A-028)

SECTION XX

WATER QUALITY MANAGEMENT AND PROTECTION

IDENTIFICATION OF POLLUTANTS (Group 05A)

70-71:05A-001
IMPACT OF AGRICULTURAL POLLUTANTS ON WATER USES,
Law, James P., Jr., and Bernard, Harold.
Robert S. Kerr Water Research Center, Ada, Oklahoma.
Transactions at the American Society of Agricultural Engineers, Vol. 13, No. 4, p 474-478, July-August 1970. 3 tab, 23 ref.

Descriptors: *Farm wastes, *Irrigation, *Salinity, *Pollutants, *Fertilizers, *Water pollution sources, Biochemical oxygen demand, Chemical oxygen demand, Disposal, Livestock, Agricultural chemicals, Aquatic life, Water quality, Fish, Dissolved oxygen, Aesthetics, Recreation, Pollutant identification.
Identifiers: *Agricultural pollutants, *Aesthetic value, Total salt, Primary contact recreation, Secondary contact recreation.

This paper discussed the water pollution potential of agricultural sources. Animal wastes, irrigation return flows, fertilizer application, and pesticides are the primary sources of agricultural pollutants. The water-quality criteria for water supplies are discussed as related to agricultural contaminants. Data is presented for the desirable and permissible limits of concentration for the various contaminants. Agriculture is responsible for a major portion of the total salt in many rivers and streams. Data is given for the proposed safe limits of water salinity for livestock. The impact that agricultural pollutants has on fish, other aquatic life, and wildlife is discussed. Examples are cited where pollutants have adversely affected fish and wildlife. Now is the time to build the cost of clean water into all of our operations.

70-71:05A-002
LEACHING OF POLLUTANTS FROM REFUSE BEDS,
Qasim, Syed R., and Burchinal, Jerry C.
Battelle Memorial Institution, Columbus, Ohio; and West Virginia University, Morgantown, Dept of Civil Engineering.
ASCE Proceedings, Journal Sanitary Engineering Division, Vol. 96, No. SA1, Paper 7078, p 49-58, February 1970. 10 p, 5 fig, 6 tab, 7 ref, append.

Descriptors: *Landfills, *Leaching, *Water pollution sources, *Path of pollutants, Percolation, Garbage dumps, Seepage, Public health, Water analysis, Evaporation, Evapotranspiration.
Identifiers: Sanitary landfill leaching.

A procedure is presented for estimating theoretically the chemical quality of leachates from sanitary landfills. A theory of column chromatography was employed to determine the leaching of chloride during the movement of water through refuse beds. Generalized breakthrough curves were used to obtain the theoretical chloride concentrations. Families of curves were then derived from experimental results, representing the ratios of various leaching materials to the theoretical chloride concentrations. A comparison of experimental and theoretical results shows good agreement. The method can be applied to the field study of existing landfills to determine the chemical composition of polluting liquid during the leaching process, if the cumulative precipitation, evaporation, evapotranspiration, runoff coefficients, and the depth of refuse beds are known.

70-71:05A-003
EXISTING LEVELS OF NITRATES IN WATERS - THE ILLINOIS SITUATION,
Harmeson, Robert H., and Larson, T. E.
Illinois State Water Survey, Urbana, Chemistry Section.

Proceedings 12th Sanitary Engineering Conference on Nitrate and Water Supply: Source and Control, February 11-12, 1970. University of Illinois, Urbana: Illinois University, College of Engineering Publication, p 27-39, 1970. 13 p, 5 fig, 1 tab.

Descriptors: *Nitrates, *Water pollution sources, *Illinois, *Surveys, *Monitoring, Surface waters, Groundwater, Farm wastes, Organic matter, Soil water, Path of pollutants, Public health, Sampling.

The Illinois State Water Survey has sampling programs for determining the mineral quality of ground- and surface waters in Illinois. The nitrate concentrations of streams are increasing. Since 1956, concentrations of nitrates exceeding 45 mg/liter have been found on occasion in several streams. Seasonal variation in nitrate concentrations was found in surface waters; the highest levels were found in spring and early summer. High nitrate levels are most consistently found in areas of intensive agricultural production where the soil is rich in organic nitrogen. Both soil type and extent of fertilization are important in influencing the concentration of nitrates in surface waters. Groundwater contamination by nitrogen from fertilizers is not a problem at the present time.

70-71:05A-004
AN IMPROVED DIANTHRIMIDE TECHNIQUE FOR THE DETERMINATION OF BORON IN RIVER WATERS,
Levinson, A. A.
Calgary University (Alberta), Dept of Geology.
Water Research, Vol. 5, No. 1, p 41-42, January 1971. 2 p, 6 ref.

Descriptors: *Pollutant identification, *Boron, *Surface waters, *Analytical techniques, *Colorimetry, Water analysis, Salinity, Water chemistry.
Identifiers: *Boron determination.

A modified dianthrimide method is described which is capable of detecting as little as 0.01 mg per liter boron in river water. The procedure is based upon the use of calcium hydroxide to fix the boron; this also permits rapid evaporation of the water sample without the loss of volatile borates.

70-71:05A-005
CONTINUOUS EXTRACTION OF ORGANIC MATERIALS FROM WATER,
Goldberg, Marvin C., DeLong, Lewis, and Kahn, Lloyd.
Geological Survey, Denver, Colorado; and Federal Water Quality Administration, Edison, New Jersey.
Environmental Science and Technology, Vol. 5, No. 2, p 161-162, February 1971. 2 p, 1 fig, 3 ref.

Descriptors: *Solvent extractions, *Analytical techniques, *Water analysis, *Organic matter, *Monitoring, Solutes, Colloids, Separation techniques, Immiscibility, On-site tests, Data collections, Water quality, Organic compounds, Solvents.
Identifiers: *Dissolved organic matter sampling.

A continuous liquid solvent extractor, designed to utilize organic solvents that are heavier than water, is described. The extractor is capable of handling input rates up to 2 liters per hour and has a 500-ml. extractant capacity. Extraction efficiency is dependent upon the p-value, the two solvent ratios, rate of flow of the aqueous phase, and rate of reflux of the organic phase. Extractors can be serially coupled to increase extraction efficiency and, when coupled with a lighter-than-water extractor, the system will allow the use of any immiscible solvent.

70-71:05A-006
SPECIFIC-ION ELECTRODE DETERMINATION OF NITRATE IN SOME FRESHWATERS AND SEWAGE EFFLUENTS,
Langmuir, Donald, and Jacobson, Roger L.
Pennsylvania State University, University Park, Dept of Geochemistry and Mineralogy.
Environmental Science and Technology, Vol. 4, No. 10, p 834-838, October 1970.
2 fig, 3 tab, 6 ref.

Descriptors: *Nitrates, *Sewage effluents, *Pollutant identification, Analytical techniques, Electrochemistry, Electrodes, Membrane processes, Electrical conductance, Carbonates, Chlorides, Ions.
Identifiers: *Brucine method, Chemical interference.

Thirty-seven waters with 1.5 to 122 ppm NO sub 3- were anlayzed for NO sub 3- with a nitrate ion selective electrode and by the brucine method. Two electrode methods were evaluated. The K-gamma method involves making corrections for HCO sub 3- and Cl- and for the effect of ionic strength on Gamma NO sub 3. Cl- has a selectivity ratio of about 3 X 10-2, thus five times more serious an interference than previously reported. Gamma NO sub 3 is evaluated graphically from the specific conductance and the sample's prevalent chemical character. Agreement between the K- gamma and brucine methods was generally within 1 ppm at all NO sub 3- concentrations. An 'approximate' electrode method, gave results similar to brucine values for samples above 50 ppm of NO sub -3, but was not reliable below that value. Advantages of the electrode over the brucine method are: measurements are generally unaffected by sample color or turbidity; NO sub 3 concentrations of 1 to about 6000 ppm may be determined without sample dilution or concentration; the method is rapid and portable; procedures are simple but yield accuracy comparable to that of the brucine method; and reproducibility of measurements with the nitrate electrode is often better than plus or minus 1 percent.

70-71:05A-007
CONDUCTIVITY MEASUREMENTS MONITOR WASTE STREAMS,
Corrigan, P. A., Lyons, V. E., Barnes, G. D., and Hall, F. G.
Tennessee Valley Authority, Muscle shoals, Alabama.
Environmental Science and Technology, Vol. 4, No. 2, p 116-121, February 1970.
4 fig, 1 tab.

Descriptors: *Water pollution control, *Electrical conductance, *Stream gages, Water quality, Pollution abatement, Pollutant identification, Indicators, Water pollution sources.
Identifiers: Chemical spills, Pollution detection.

Electrical conductivity measurement is a simple and fast method for determining the relative amount of ions in water. This method is now being used to detect the presence of pollutants in industrial effluents. Using recorders, it is possible to determine concentrations and duration of waste dumpings. Investigation into the proper choice and location of the devices was carried out. Guidelines for proper installation and maintenance are presented. The cells and recorders should be checked and cleaned daily if possible. The systems proved to be very effective in detecting and reporting levels of pollution. The savings in lost chemicals soon paid for the equipment.

70-71:05A-008
FACTORS AFFECTING THE DETERMINATION OF AVAILABLE SOIL NITROGEN BY CHEMICAL METHODS: I. COMPARISON OF EXTRACTABLE WITH MINERALIZED NITROGEN,
Verstraeten, L. M. J., Vlassak, K., and Livens, J.
Louvain University, Belgium.
Soil Science, Vol. 110, No. 5, p 299-305, November 1970. 4 fig, 2 tab, 12 ref.
(See 70-71:02G-071)

70-71:05A-009
ISSUES IN ENVIRONMENTAL QUALITY,
Gratto, C. P.
Iowa State University, Ames.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 45-46, March-April 1971.

Descriptors: *Pollution abatement, Pollutants, Environmental effects.
Identifiers: Environmental quality.

Recent interest in environmental quality has produced a large number of related and relative terms to describe the situation. An attempt is made in the article to tie these terms together. Also, a number of environmental issues are presented. An analogy between our environment and a simplified system is presented in an effort to develop the points in a more simple manner.

70-71:05A-010
GEOCHEMICAL EFFECTS OF MINING POLLUTION ON THE STREAMS OF SOUTHEAST MISSOURI,
Bolter, Ernst, and Tibbs, Nicholas H.
Missouri University, Rolla; and Missouri Water Resources Research Center, Rolla.
Available from NTIS as PB-197 531, $3.00 in paper copy, $0.95 in microfiche.
Completion Report, Missouri Water Resources Research Center.

Descriptors: *Heavy metals, *Mine wastes, *Pollutant identification, Water pollution, Mining, Geochemistry, Streams, Analytical techniques, Missouri, Copper.
Identifiers: Lead, Zinc, New Lead Belt (Missouri).

Streams in the 'New Lead Belt' of SE Missouri were analyzed for copper, lead and zinc. This area, which a few years ago was sparsely settled and not industrialized, is rapidly developing into the largest lead-zinc mining district of the United States. The data of this study were compared to the results of a pre-mining investigation to determine if the mining activity contributed to the pollution of the streams by heavy metals. Data from an individual mine indicate that the milling waste waters can increase the heavy metal content of the receiving stream up to seven times. However, the heavy metal content of the stream decreases to background concentrations within a distance of three miles. The summarized data of the total area do not indicate a noticeable increase of the heavy metal content in the streams. The average concentrations in the streams at the time of the present investigation were 5.3 ppb for copper, 8.9 ppb for lead and 9.5 ppb for zinc; the calcium content in the range of 2.45 ppm; the magnesium content in the range of 1.30 ppm; the pH of the streams ranges from 7.0-8.8. It is concluded that the mining activity presently does not significantly polute the streams with heavy metals.

70-71:05A-011
SALINITY AND WATER USE,
Talsma, T., and Philip, J. R.
The MacMillan Press, London, England. 1971. 296 p, 2 append.
(See 70-71:01B-002)

70-71:05A-012
THE TRANSPORT OF SALT IN RIVERS AND ESTUARIES,
Wood, I. R.
New South Wales University, Manly Vale, Australia, Water Research Laboratory.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 141-157. 8 fig, 30 ref.
(See 70-71:01B-005)

70-71:05A-013
ECONOMIC AND SOCIAL ASPECTS OF SALINE WATER USE AND MANAGEMENT,
Callinan, B. J., and Webster, R. G.
Gutteridge, Haskins, and Davey; Melbourne, Victoria, Australia.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 227-242. 4 fig, 3 tab, 5 ref.
(See 70-71:03C-017)

70-71:05A-014
ADMINISTRATIVE AND LEGAL ASPECTS OF SALINE WATER USE AND MANAGEMENT,
Clark, S. D., and Meacham, I.
Melbourne University, Victoria, Australia.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 243-254.
(See 70-71:03C-018)

70-71:05A-015
IMPLICATIONS OF THE PRESENT STATE OF SCIENTIFIC KNOWLEDGE FOR TECHNICAL MANAGEMENT,
England, H. N.
Water Conservation and Irrigation Commission, Sydney, New South Wales, Australia.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 257-273, 9 ref.
(See 70-71:02K-044)

70-71:05A-016
SALINITY AND WATER USE: FUTURE RESEARCH DIRECTIONS,
Martin, A. E.
Commonwealth Scientific and Industrial Research Organization, Saint Lucia, Queensland, Australia, Soils Division, Cunningham Laboratory.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 275-284. 2 ref.
(See 70-71:02K-045)

SECTION XXI

WATER QUALITY MANAGEMENT AND PROTECTION

SOURCES OF POLLUTION (Group 05B)

70-71:05B-001
MOVEMENT OF PESTICIDES BY RUNOFF AND EROSION,
Haan, C. T.
Kentucky University, Lexington, Dept of Agricultural Engineering.
American Society of Agricultural Engineers Transactions, Vol. 14, No. 3, p 445-447, 449, May-June 1971. 3 fig, 6 tab, 7 ref.

Descriptors: *Path of pollutants, *Pesticides, *Erosion, *Overland Flow, Pesticide residues, Aldrin, Dieldrin, DDT, Laboratory tests, Adsorption, Soils, Soil erosion.

The movement of aldrin, dieldrin and DDT by runoff and erosion was studied on ten small, fallow, field plots under controlled conditions. The concentrations of the pesticides in the eroded soil was on the order of 10 to 30 ppm while that in the runoff water was only 1 to 70 ppb. The sediment carried more than twice as much pesticide from the plot as did the water. These concentrations were present immediately below a fallow area sprayed with the pesticide. Applying aldrin, dieldrin or DDT to the soil surface shortly before a rainfall produces no more potential for pesticides in the runoff water and eroded soil than applying the pesticide several days before a rainfall.

70-71:05B-002
CONCENTRATIONS OF POLLUTANTS IN AGRICULTURAL RUNOFF,
Wells, Dan M., Huddleston, Ellis W., and Rekers, Robert G.
Texas Tech University, Lubbock, Dept of Civil Engineering; and Texas Tech University, Lubbock, Dept of Chemistry.
Water Resources Bulletin, Vol. 7, No. 1, p 124-132, February 1971. 9 p, 3 tab.

Descriptors: *Lakes, *Water quality, *Texas, *Farm wastes, *Water pollution sources, Runoff, Nutrients, Solutes, Nitrates, Phosphates, Herbicides, Pesticides, Playas, Overland flow.
Identifiers: Agricultural runoff.

Eighteen rural lakes in Lubbock County, Texas, were sampled on a routine basis following runoff-producing rainfall for a period of approximately eighteen months to determine whether or not runoff from intensively farmed agricultural areas contained significant concentrations of nitrates, phosphates, herbicides, or insecticides. An additional fifteen lakes lying within a triangle bounded by the cities of Plainview, Canyon, and Hereford, Texas, were sampled one time during the summer of 1969 to provide additional data regarding the nature and extent of the potential problem in an area with a different soil type and a slightly different cropping pattern. Based on results of detailed analyses of approximately two hundred samples of water collected from the lakes and an equal number of sediment samples collected from the same lakes at the same time, it appears that the concentrations of all chemical pollutants in runoff from agricultural lands in the High Plains are well below the allowable concentrations for drinking water.

70-71:05B-003
SEDIMENT IN RELATION TO WATER QUALITY,
Grissinger, E. H., and McDowell, L. L.
Agricultural Research Service, Oxford, Mississippi, Sedimentation Laboratory.
Water Resources Bulletin, Vol. 6, No. 1, p 7-14, January-February 1970. 8 p, 45 ref.

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Descriptors: *Water quality, *Sediments, *Water chemistry, *Path of pollutants, Ion exchange, Clay minerals, Particle size, Suspended load, Turbidity, Sediment yield, Sediment load, Erosion, Colloids, Sorption, Sediment transport, Diffusion, Mass transfer.
Identifiers: *Sediment-water quality relations.

The relation between sediment and water quality involves the individual relations between sediment and the physical, chemical, and biological characteristics of water as these characteristics determine the suitability of water for an intended use. Both the physical and chemical properties of fine-grained sediments must be considered in evaluating these relations, whereas only the physical properties of coarse-grained sediments are significant. Most of the literature concerning this subject has considered sediment only as a physical entity. In amount, it is the prime pollutant and is one of the major considerations in evaluating the suitability of water for an intended use. Losses in the United States from sediment and associated flood water damages are measured in billions of dollars annually. Sediments also indirectly affect water suitability through their physical influences on biological activity. Fine-grained sediments, that is, clay minerals and amorphous and organic materials, have chemically active surfaces. These sediments may either sorb ions from solution or release ions to solution depending upon the chemical environment. The ternary system--sediment-water-dissolved chemical load--was studied to define its influence on the biological characteristics of water and the suitability of water for various long-term uses.

70-71:05B-004
GROUND-WATER POLLUTION POTENTIAL OF A LANDFILL ABOVE THE WATER TABLE,
Apgar, M. A., and Langmuir, D.
Pennsylvania State University, University Park, Dept of Geosciences.
Proceedings of the National Ground Water Quality Symposium, Denver, Colorado, August 25-27, 1971: Ground Water, Vol. 9, No. 6, p 76-94, November-December 1971, 24 fig, 4 tab, 39 ref.

Descriptors: *Landfills, *Water pollution sources, *Karst, *Pennsylvania, Garbage dumps, Waste disposal, Oxygen demand, Solutes, Path of pollutants, Biodegradation, Leaching, Percolation, Groundwater movement.
Identifiers: *State College (Pennsylvania).

A study of the character and movement of landfill leachate through unsaturated soil was begun in 1967 at the State College (Pennsylvania) Regional Sanitary Landfill, which has operated since 1962. The landfill occupies a gently sloping valley with a water table more than 200 feet below land surface. Precipitation averages about 37 inches as rain per year. Residual sandy-clay to sandy-loam soils range from a few feet to greater than 70 feet in thickness on a sandy dolomite bedrock. The quality and quantity of leachate beneath the landfill varies considerably with the topographic setting of landfill trenches or cells. Leachates 2 feet under an upslope cell which received only direct precipitation, had the following maximum values 3-12 months after refuse burial: specific conductance 8445 micromhos, Cl 1890 mg/liter, BOD 3300 mg/liter. NH3 -N 540 mg/liter, and total Fe 225 mg/liter. Water infiltrated a downslope cell, saturating the refuse. Even after moving downward in the soil to a depth of 36 feet in 7 years, the leachate beneath this cell had a conductance of 6600 micromhos, 600 mg/liter Cl, over 9000 mg/liter BOD, 40 mg/liter NH3-N, and 100 mg/liter total Fe. Leachate beneath instrumented cells is moving downward in the subsoil at the rate of 6-11 ft/yr. Highly contaminated leachate moves to depths of 50 feet or more in soils beneath downslope cells. Improper design of landfills emplaced above the water table can result in serious groundwater pollution.

70-71:05B-005
PESTICIDE CONTAMINATION OF A SHALLOW BORED WELL IN THE SOUTHEASTERN COASTAL PLAINS,
Lewallen, M. J.
South Piedmont Conservation Research Center, Watkinsville, Georgia.

Proceedings of the National Ground Water Quality Symposium, Denver, Colorado, August 25-27, 1971: Ground Water, Vol. 9, No. 6, p 45-48, November-December 1971. 4 fig, 4 tab, 8 ref.

Descriptors: *Water pollution sources, *Pesticides, *Water wells, *Path of pollutants, Pesticide residues, Soil contamination, Leaching Translocation, Atlantic Coastal Plain.

A shallow farm well was contaminated with persistent pesticides when contaminated soil was used as backfill material around the well casing. The well location was less than 25 feet from a site previously used for flushing an insecticide sprayer. Pesticide level in the water was monitored for more than 4 years, during which a gradual decline in concentration has occurred. Soil core samples taken in the area surrounding the well indicate relatively high surface contamination but very little downward movement. Sediment samples from the bottom of the well exhibited highest concentration of all samples.

70-71:05B-006
WHERE DOES WATER QUALITY IMPROVEMENT BEGIN,
Jones, Elmer E., Jr.
Agricultural Research Service, Beltsville, Maryland. Livestock Engineering and Farm Structures Research Branch.
Ground Water, Vol. 9, No. 3, p 24-28, May-June 1971. 5 p, 5 fig, 10 ref.

Descriptors: *Groundwater movement, *Path of pollutants, *Water pollution sources, *Water wells, Malenclaves, Water sources, Domestic water, Well regulations.
Identifiers: Domestic well protection.

Most groundwater aquifers have a multibarrier natural defense system. With all these natural defenses, in most cases of contamination, the well itself is the path of entrance for the contamination. Only in very rare circumstances is it economically justified to substitute disinfection for adequate protection of a groundwater source. Rapid changes in well water quality with pumping time indicate less than optimum construction. Poorly constructed and abandoned wells serve as unauthorized and uncontrolled groundwater recharge points and have a degrading effect on groundwater quality. Water quality improvement should begin with excluding water of undesirable quality from the source of supply. For the home owner and farmer to profit from this ideal it must be accepted by well drillers, water conditioning dealers, and county and State health departments.

70-71:05B-007
STATISTICAL EVALUATION OF SALINITY AND NITRATE CONTENT AND TRENDS BENEATH URBAN AND AGRICULTURAL AREA - FRESNO, CALIFORNIA,
Nightingale, Harry I.
Agricultural Research Service, Fresno, California, Groundwater Recharge Field Station.
Groundwater, Vol. 8, No. 1, p 22-28, January-February 1970. 7 p, 6 fig, 5 tab, 8 ref.

Descriptors: *Water pollution sources, *Groundwater, *California, *Nitrates, *Salinity, Water wells, Aquifers, Irrigation water, Fertilizers, Urbanization, Statistical methods, Surveys, Conductivity, Farm wastes, Regression analysis.
Identifiers: Fresno (California).

The salinity and nitrate content of well water for an urban zone (Fresno-Clovis, California) and the immediate surrounding irrigated agricultural zone were compared using data for 1950 through 1967. Time trends in these water chemical properties were evaluated statistically by dividing the 18-year period into three 6-year periods. Salinity of the urban zone groundwater has increased with time, whereas that of the agricultural zone has fluctuated considerably. Possible reasons for changes are discussed. The nitrate content of well water from both zones has increased with time, with water from the agricultural zone showing the greatest increase.

70-71:05B-008
THE MOVEMENT OF BACTERIA AND VIRUSES THROUGH POROUS MEDIA,
Romero, John C.
Colorado Division of Water Resources, Denver, Ground Water Section.
Ground Water, Vol. 8, No. 2, p 37-38, March-April 1970. 12 p, 3 fig, 4 tab, 26 ref, append.

Descriptors: *Path of pollutants, *Bacteria, *Viruses, *Porous media, *Groundwater movement, Seepage, Water pollution sources, Filtration, Reviews, Surveys, Sanitary engineering, Waste disposal.
Identifiers: Well sanitation.

This report is the result of a request by the State Board of Examiners of Water Well and Pump Installation Contractors. The Board is in the process of formulating a more reasonable set of guidelines which control the location of wells designed to produce water for human consumption and/or food processing with respect to potential or existing sources of ground-water pollution. The pollution of groundwater supplies appears belatedly and often is not recognized until a relatively large area has been contaminated. Soils and aquifer materials have capacity to remove or 'filter' some types of contaminants. The results of several pertinent groundwater pollution investigations are briefly described and current and potential standards for governing 'safe distances' between domestic food processing wells and sources of potential or existing pollution are given. The recommendations are meant to emphasize the fact that no one set of distances are adequate and reasonable for all conditions. Whenever possible the safe-distance between a subject well and a source of potential or existing pollution should be based on local conditions. It is important that we develop knowledge that will permit continued use of the soil mantle as a waste-water treatment system and at the same time permit continued use of ground water for human consumption and/or food processing. Functional, legal, administrative and engineering mechanisms must be developed to maintain this combined usage.

70-71:05B-009
DISSOLVED SOLIDS - DISCHARGE RELATIONSHIPS, 2. APPLICATIONS TO FIELD DATA,
Hall, Francis R.
New Hampshire University, Durham, Institute of Natural and Environmental Resources.
Water Resources Research, Vol. 7, No. 3, p 591-601, June 1971. 11 p, 5 fig, 4 tab, 11 ref.

Descriptors: *Mixing, *Dissolved solids, *Discharge (Water), *Path of pollutants, Aqueous solutions, Dispersion, Diffusion, Mathematical models, Data processing, Streamflow, Turbulent flow, Open channel flow, Waste dilution.
Identifiers: Dissolved solids-discharge relations.

Six mixing models and a number of equations derived from them have been proposed for some possible dissolved solids-discharge relationships in streams. The equations can be put in a form suitable for statistical analysis by digital computer. In actual application, however, a major problem arises in determining which equation or model is most applicable because the data tend to fit two or more equations equally well. A particular difficulty is encountered in deciding whether a constant component of dissolved solids is present. This decision is most critical when only total dissolved solids or electrical conductivity is used for concentration. An examination of other chemical data, if available, along with knowledge of the stream help decide which model is most suitable. Other problems may arise from factors such as nonrandom trends and variations in the storage volume-discharge relationship. Under these circumstances, an extension of the equations beyond the range of actual data or inferences about physical or chemical significance of the equations or constant terms should be made with caution.

70-71:05B-010
MIGRATION OF POLLUTANTS IN A GLACIAL OUTWASH ENVIRONMENT,
Crosby, James W., III, Johnstone, Donald L., and Fenton, Robert L.
Washington State University, Pullman.
Water Resources Research, Vol. 7, No. 1, p 204-208, February 1971. 5 p, 5 fig, 11 ref.

Descriptors: *Path of pollutants, *Glacial drift, *Farm wastes, *Confinement pens, Coliforms, Nitrates, Nutrients, Solutes, Soil water movement, Groundwater, Washington, Water pollution sources, Chlorides, Soil moisture.
Identifiers: Feedlots (Cattle), Outwash (Glacial).

A test drilling program was conducted at a dairy in the Spokane Valley, Washington, to determine the effects of feedlot operation on groundwater quality. Coliform bacteria, enterococci, and fecal coliforms were found to disappear within a relatively few feet of the ground surface. Chlorides and nitrates, however, were persistent in depth and may actually reach the groundwater body. The low natural moisture content of the soil, coupled with the apparent high moisture tensions, suggests that soil moisture is not presently moving downward in the system. It is concluded that the downward migration of inorganic chemicals from the feedlot environment must represent an early phase of the operation, which is arrested as organic matters are formed in near-surface layers.

70-71:05B-011
NUTRIENTS IN STREAMS DRAINING WOODLAND AND FARMLAND NEAR COSHOCTON, OHIO,
Taylor, A. W., Edwards, W. M., and Simpson, E. C.
Agricultural Research Service, Beltsville, Maryland, Soils Laboratory.
Water Resources Research, Vol. 7, No. 1, p 81-89, February 1971. 9 p, 3 fig, 6 tab.

Descriptors: *Nutrients, *Runoff, *Forests, *Farms, *Ohio, Nitrogen, Nitrates, Phosphates, Potassium, Data collections, Water quality, Path of pollutants, Eutrophication, Appalachian Mountain Region, Farm wastes, Statistical methods, Fertilizers, Leaching, Water pollution sources.
Identifiers: Woodlands, Farm lands, Coshocton (Ohio).

Nitrogen, phosphate, and potassium concentrations were measured in streams draining woodland and farmland watersheds at Coshocton, Ohio 1966 through 1969. Temporal variations in the nutrient concentrations were much smaller than the changes in the rate of streamflow. No relationship was found between any nutrient concentration and streamflow, and no seasonal changes in concentration were detected. Nutrient losses from farmland were significantly greater than those from woodland. The nitrate-N concentration in the farm runoff was below 2 ppm except for one short period when it rose to 10 ppm. The input of nitrogen in the rain was greater than the loss in runoff from both watersheds. The average concentration of phosphate in runoff was 22 ppb (of P) from the farm and 15 ppb from the woodland. The analysis of the data shows that the total nutrient losses cannot be calculated meaningfully unless both hydrologic and chemical data are available. The volume of water flow is the most important variable in this calculation.

70-71:05B-012
NUMERICAL SOLUTION TO THE CONVECTIVE DIFFUSION EQUATION,
Oster, C. A., Sonnichsen, J. C., and Jaske, R. T.
Battelle-Northwest, Richland, Washington
Water Resources Research, Vol. 6, No. 6, p 1746-1752, December 1970. 7 p, 3 fig, 1 tab, 4 ref.

Descriptors: *Mixing, *Numerical analysis, *Diffusion, *Dispersion, *Path of pollutants, Water pollution effects, Convection, Translocation, Mathematical studies, Streamflow, Turbulent flow, Computer programs.
Identifiers: *Pollutant transport.

A numerical solution to the convection diffusion equation is discussed. The case examined treats a conservative waste or pollutant, although the system is flexible enough to accommodate nonconservative substances. The numerical approximation appears stable and can be extended to include analysis of an n-dimensional array.

70-71:05B-013
A GENERAL NUMERICAL SOLUTION OF THE TWO-DIMENSIONAL DIFFUSION-CONVECTION EQUATION BY THE FINITE ELEMENT METHOD,
Guymon, G. L., Scott, V. H., and Herrmann, L. R.
California University, Davis.
Water Resources Research, Vol. 6, No. 6, p 1611-1617, December 1970. 7 p, 3 fig, 11 ref.

Descriptors: *Diffusion, *Convection, *Linear programming, Mathematical studies, Equations, Computer programs, Numerical analysis, Dispersion, Porous media, Flow, Open channel flow.
Identifiers: *Finite element analysis.

The two-dimensional diffusion-convection equation, together with the appropriate auxiliary conditions, is used to describe approximately the motion of dissolved constituents in porous media flow, dispersion of pollutants in streams and estuaries, energy transfer in reservoirs, and other natural transport processes. The two-dimensional diffusion-convection equation, with an assumed set of auxiliary conditions, is converted to a variational principle for systems that do not involve mixed partials. The variational principle is in turn solved by the Ritz procedure by dividing the domain of interest into an arbitrary number of finite triangular elements. Within each element the unknown function states are represented by a first order space polynomial. The resulting system of first order linear equations is then solved by numerical differentiation using the Adams-Moulton multistep predictor-corrector method.

70-71:05B-01
LEACHING OF CROP RESIDUES AS A SOURCE OF NUTRIENTS IN SURFACE RUNOFF WATER,
Timmons, D. R., Holt, R. F., and Latterell, J. J.
Agricultural Research Service, Morris, Minnesota; and Minnesota University, Morris.
Water Resources Research, Vol. 6, No. 5, p 1367-1375, October 1970. 9 p, 8 tab, 8 ref.

Descriptors: *Leaching, *Nutrients, Runoff, *Water pollution sources, Path of pollutants, Plants, Nitrogen, Phosphorus, Soil-water-plant relationships, Water quality, Eutrophication, Cycling nutrients.
Identifiers: Crop residues, Stubble.

Nitrogen and phosphorus losses were determined in plant leachates from alfalfa, Kentucky bluegrass, barley straw stubble, and oats straw stubble. Plant samples harvested from the field were either leached immediately or were desiccated by drying or freezing before leaching. The extraction of soluble nitrogen and soluble phosphorus in leachates from alfalfa and bluegrass was greatly increased by drying or freezing. These same treatments, however, released only small amounts of soluble phosphorus from barley and oats straw. Estimated soluble nutrient losses indicate that leaching of alfalfa and bluegrass by surface runoff water could contribute substantial amounts of nitrogen and phosphorus to lakes and streams.

70-71:05B-015
STEADY DISPERSION ACROSS AN INTERFACE IN A POROUS MEDIUM,
Verruijt, A.
Technische Hogeschool, Delft (Netherlands).
Journal of Hydrology, Vol. 14, No. 3/4, p 337-347, December 1971. 4 fig, 8 ref.

Descriptors: *Dispersion, *Mixing, *Path of pollutants, *Interfaces, *Porous media, Groundwater movement, Saline water-freshwater interfaces, Flow, Density, Viscosity, Tracers, Saline water intrusion, Numerical analysis.

In two problems of steady dispersion across an interface, originally non-polluted fluid flowed parallel to the interface. This fluid is polluted by dispersion across the interface. A flushing effect exists when the polluted fluid on the other side of the interface is stationary. The flushing effect may lead to a reduction of the width of the dispersion zone. The analysis is approximate in the sense that it is assumed that the tracer distribution is discontinuous across the interface. As such a discontinuity is consistent with a discontinuous flow field the results may well be sufficiently accurate.

70-71:05B-016
WATER QUALITY EFFECTS OF LEACHING FROM SUBMERGED SOILS,
Keup, Lowell E., McKee, Gerald D., Raabe, Edward W., and Warner, Richard W.
National Field Investigations Center, Cincinnati, Ohio.
Journal of American Water Works Association, Vol. 62, No. 6, p 391-396, June 1970. 6 p, 6 fig, 2 tab.

Descriptors: *Leaching, *Organic soils, *Water quality control, *Reservoirs, *Reservoir design, Humus, Organic matter, Iron, Manganese, Water quality, Water chemistry.
Identifiers: Cape Fear River (North Carolina).

Impounding water may result in the leaching of undesirable materials from the inundated soils. The Northeast Cape Fear River to be impounded in Kornegay Reservoir contained high color values (100 + units), high concentrations of lignin (13.6 mg/l), and concentrations of nitrogen and manganese that might interfere with water uses. This water could leach additional quantities of lignin, iron, manganese, and total phosphorus from the leaf litter covering the reservoir site. Experiments indicated that iron and manganese were leached at a greater rate under anaerobic conditions. With clear waters, (color, 18 units), substantial increases in materials leached were observed in either aerobic or anaerobic waters. The one exception was manganese which decreased substantially in the aerobic waters. It is recommended that organic-rich materials, especially leaf litter, be removed or plowed into the soil to prevent leaching of excessive iron, manganese, and lignin to the water. If practical, organic rich soils such as muck should be removed or buried. In addition, provisions should be made for multi-level water supply intakes.

70-71:05B-017
DISTRIBUTION OF DDT AND TOXAPHENE IN HOUSTON BLACK CLAY ON THREE WATERSHEDS,
Swoboda, Allen R., Thomas, Grant W., Cady, Foster B., Baird, Ralph W., and Knisel, Walter G.
Texas A and M University, College Station, Dept of Soil and Crop Science.
Environmental Science Technology, Vol. 5, No. 2, p 141-145, 1971. 4 fig, 4 tab, 9 ref.

Descriptors: *Insecticide, *Distribution pattern, DDT, Leaching, Clays.
Identifiers: Black, Clay, Distribution, Houston, Movement, Texas, Toxaphene, Watersheds.

The movement and distribution of DDT and Toxaphene in a heavy clay soil was studied on three Blackland Prairie watersheds in Texas. Less than 16% of the DDT (total of p, p-DDT, DDE, and DDD) and less than 22% of the Toxaphene applied over a 10-yr period was recovered in the top 5 ft of the soil. Between 60 and 75% of the recovered DDT was found in the top 12 in. of soil, but 90 to 95% of the Toxaphene was found in the upper 12 in. Movement of DDT into the lower soil depths was attributed to top soil being washed into the large vertical cracks of the vertisol by rainfall. Leaching was also considered a factor in the downward movement of DDT, since a seep was found to contain from 0.2 to 1.2 ppb of DDT.

70-71:05B-018
TRANSPORT OF MINERAL OIL COMPONENTS TO GROUNDWATER--I. MODEL EXPERIMENTS ON THE TRANSFER OF HYDROCARBONS FROM A RESIDUAL OIL ZONE TO TRICKLING WATER,
Van der Waarden, M., Bridie, A. L. A. M., and Gruenewoud, W. M.
Koninkliyke/Shell-Laboratorium, Amsterdam (Netherlands).
Water Research, Vol. 5, No. 5, p 213-226, May 1971. 14 p, 7 fig, 3 tab, 12 ref.

Descriptors: *Path of pollutants, *Leaching, *Soil water movement, *Oily water, *Groundwater recharge, Model studies, Hydraulic models, Oil wastes, Water pollution sources.
Identifiers: *Oil spills.

Oil spills in soils become immobile after some time. Subsequent rainfall may then leach out water-soluable components, which are carried downward. In laboratary experiments a pack of non-adsorbing glass particles was used as a soil model to study the transfer of oil components to groundwater. Oil was injected into a zone with residual water saturation of this model and allowed to disperse freely. Subsequently water was allowed to trickle through the pack and the drain water, which did not contain any free oil, was analyzed for contaminants. Experiments were carried out with a gas oil raffinate containing very small amounts of 2-isopropylphenol as a model for transferable components and with actual mineral oil products: gasoline, kerosene and gas oil. In all the experiments water-extractable components were leached out from an oil zone by trickling water at a rate determined by the partition coefficient of the components and by the water/oil ratio. When the glass particles were replaced by natural dune sand the transfer of oil components was delayed by adsorption and their concentration in the drain water decreased correspondingly. Under field conditions these effects of adsorption might be much stronger; in addition, chemical or biological oxidation and evaporation may also to some extent determine the fate of oil in soil.

70-71:05B-019
WATER-SOLUBLE NO 3-NITROGEN, PO 4-PHOSPHORUS, AND TOTAL SALT BALANCES ON A LARGE IRRIGATION TRACT,
Carter, D. L., Bondurant, J. A., and Robbins, C. W.
Agricultural Research Service, Kimberly, Idaho, Snake River Conservation Research Center.
Soil Science Society of America Proceedings, Vol. 35, No. 2, p 331-335, March-April 1971. 5 p, 1 fig, 4 tab, 25 ref.

Descriptors: *Water pollution sources, *Fertilizers, *Return flow, *Phosphates, *Nitrates, Salinity, Nutrients, Idaho, Leaching, Irrigation water, Path of pollutants.
Identifiers: *Snake River (Idaho).

Return flow from a 82,030-ha tract of calcareous silt loam soils irrigated with water diverted from the Snake River in southern Idaho increased the downstream total soluble salt and NO 3 loads, but decreased the downstream PO 4 load. Under the existing water management practice, 50% of the total input water returned to the Snake River as subsurface drainage. Net total soluble salt output was 2.4 metric tons/ha and, on the average, was considerably greater than necessary to maintain a salt balance. Net NO 3 output was 33 kg/ha. Only about 30% as much PO 4 left the tract via drainage water as entered the tract in irrigation water. As water passed through the soil, PO 4 was removed by chemical reactions in the soil, thus decreasing the concentration in the subsurface drainage water and decreasing the downstream PO 4 load. Applied P fertilizer was not leached into the drainage water.

70-71:05B-020
PHOSPHATE MOVEMENT IN SURFACE RUN-OFF WATER,
Gilchrist, A. N., and Gillingham, A. G.
Ministry of Works, Nelson (New Zealand). Moutere Soil Conservation Station.
New Zealand Journal of Agricultural Research, Vol. 13, p 225-231, 1970. 2 fig, 3 tab, 8 ref.

Descriptors: *Phosphate, *Surface run-off, *Rainfall, *Fertilizers, Path of pollutants, Nutrients.
Identifiers: New Zealand.

Intense simulated rainfall was applied to small plots topdressed in strips with aerial superphosphate at 4 cwt per acre to determine how much and, within the limits of the apparatus, how far the water-soluble fraction could be moved down slope in surface run-off water. It was found that 3 in. of rainfall (2 in. of run-off) in 1 hr could remove 28% of the fertilizer placed in a 3 in. wide band at a distance of 2 1/4 - 2 1/2 ft up slope from a collecting tray.

70-71:05B-021
MANAGEMENT OF NUTRIENTS ON AGRICULTURAL LAND FOR IMPROVED WATER QUALITY,
Zwerman, P. J., Bouldin, D. R., Greweling, T. E., Klausner, S. D., Lathwell, D. J., and Wilson, D. O.
Cornell University, College of Agriculture and Life Sciences, Ithaca, New York, Dept of Agronomy.

Descriptors: *Surface runoff, *Crop rotation, *Nutrient losses, Manure and fertilizer application, Rainfall simulator.
Identifiers: *Nutrient losses, *Surface runoff, *Crop management.

A rain fall simulator was utilized to determine the effects of 2, 10, and 25 year storm frequencies on losses of water, soil and nutrients from plots subjected to different crop rotations, fertilizer schemes and manure applications. Crop rotations, rates of fertilizer and manure were compared. Simulations were made on freshly tilled soil. Comparative erosion losses were as follows: continuous sod < corn - alfalfa rotations < continous corn. Fertilizer alone tended to increase runoff, but this effect was overcome when fertilizer was used with manure. Continuous recording of surface and subsurface flow and subsequent losses of nutrients to the environment was conducted on larger plots. Rate and time of fertilization determined the plant nutrients lost. Returning crop residues to the soil improved water infiltration, increasing deep seepage losses. Proper timing of fertilizer applications could control adverse environmental effects. Phosphorous inputs into cultural media as it related to algal growth was studied. Sustained concentration determined the biomass of phosphorous.

70-71:05B-022
NUTRIENTS FROM TILE DRAINAGE SYSTEMS,
Glandon, Lawrence R.
Department of Water Resources, Fresno, California, San Joaquin District.
Bio-Engineering Aspects of Agricultural Drainage, 90 p. 18 fig, 29 tab, 30 ref.

Descriptors: *Agricultural waste, *Tile drainage, Nutrients, Nitrates, Phosphates, Denitrification, Fertilization, Irrigation Practices.
Identifiers: *San Joaquin Valley, California, *Composited drainage, *Nutrient variability, Indigenous nutrients, Residual nitrogen.

Tile drainage systems of the San Joaquin Valley were monitored for nutrients (nitrogen and phosphorus) to determine the algal growth potential (AGP) of the waste, and the degree of treatment required for removal of AGP. The objectives were to determine: (1) the average nutrient concentrations in tile drainage, (2) the magnitudes of annual, areal and seasonal variability of nutrients and discharges, (3) if a possible correlation exists between nutrients and agricultural practices, and (4) if existing soil conditions influence nutrient concentrations and flows. Average discharges and nutrient concentrations were calculated for different years, months and areas of interest (valleywide, major tiled areas, physiographic positions and soils). Average nutrient concentrations in the composited drainage from the Valley were found to be 19.[illegible] mg/l for nitrogen (NO_3-N) and 0.09 mg/l for phosphorus (PO_4-P); average discharge was 1.4 ac-ft/ac/yr. Nutrient levels in the composited drainage did not change appreciably with time. Variability of nutrients was observed for different seasons; a twofold decrease in nutrients was attributed to dilution by irrigation and denitrification. N was three times more concentrated in drainage from one cut of four major tiled areas investigate . The high N levels were attributed more to indigenous concentrations in certain alluvial fan soils and their parent materials than fertilization. Low N levels found in drainage from basin soils were believed caused by denitrification. P was seven times higher in the drainage from the southermost area than the other areas investigated. These extraordinarily high levels (0.69 mg/l) were attributed to indigenous concentrations in certain soils made available by anaerobic soil conditions. High discharge in the northermost area (2.3 ac-ft/ac) was believed to be caused by rapid lateral hydraulic conductivity and surrounding irrigation influence.

70-71:05B-023
STREAM ENRICHMENT FROM FORM OPERATIONS,
Minshall, N. E., Witzel, S. A., and Nichols, M. S.
Wisconsin University, Madison, Department of Agricultural Engineering.
American Society of Civil Engineers, Journal of the Sanitary Engineering Division, Vol. 96, No. SA2, Proc. Paper 7238, p 513-524, 1970. 5 tab, 2 fig, 4 ref.

Descriptors: *Runoff, *Nutrients, Corn, Fertilizers, Soil erosion, Water pollution, Sanitary engineering.
Identifiers: Winter manure applications, Nutrient wastes.

Data for a 3-year period, 1967 to 1969, show the effect of applying manure at various times of the year on the plant nutrients lost in surface runoff. Two of these years, 1967 and 1968, probably represent the extremes with regard to nutrient losses from winter manure applications. The December to March runoff from rain and melting snow was about 3 in. in 1967 and 1969, but only 0.08 in. in 1968. A rain of 0.75 in. on bare frozen ground within 2 hours after the 1967 winter manure application produced a 100 percent runoff and high nutrient losses. Plots receiving no manure lost more plant nutrients, N, P, than those receiving manure which was incorporated into the soil immediately after application. Plots receiving winter manure lost nearly 3 times as much N and P and about 5 times as much K as the summer manured plots.

70-71:05B-024
SURFACE WATER QUALITY IS INFLUENCED BY AGRICULTURAL PRACTICES,
Holt, R. F.
Agricultural Research Service, Morris, Minnesota.
Paper No. 71-740, presented at the 1971 Winter Meeting of the American Society of Agricultural Engineers, Chicago, Illinois, December 7-10, 1971. 3 tab, 34 ref.

Descriptors: *Water quality, *Pollutants, *Water pollution, *Water pollution sources, Farm wastes, Watershed management, Land management, Watersheds, Soil amendments, Fertilization.

Fertilization, animal waste handling, soil amendments and cropping practices can all influence the quality of water that runs off an agricultural watershed. Maintenance of high quality surface water demands the development of practices which can minimize the nutrient, pesticide, manure and sediment loading of water impoundments. The physical trapping or tying down of solid particles can control sediment delivery but not dissolved substances. Utilization of the sorptive capacity of the soil offers a mechanism for controlling the movement of soluable contaminants into water supplies.

70-71:05B-025
ADSORPTION AND TRANSPORT OF AGRICULTURAL CHEMICALS IN WATERSHEDS,
Frere, M. H.
Agricultural Research Service, Durant, Oklahoma, United States Department of

Agriculture-SWC.
Oral Paper, presented at the 1971 Winter Meeting American Society of Agricultural Engineers, Chicago, Illinois, December 7-10, 1971. 1 fig, 12 ref.

Descriptors: *Path of pollutants, Leaching, Adsorption, Watershed, Soil-water-plant system, Pollutants, Chemicals.

A descriptive model of the pathways of chemicals in the soil-water-plant system is used to catalogue the properties of agricultural chemicals that are important to their movement in watersheds. The chemical interactions dictate the pathways to be followed while the behavior of water controls the time and amount of movement.

70-71:05B-026
AGRICULTURALLY-POLLUTED IRRIGATION WATER AS A SOURCE OF PLANT PARASITIC NEMATODE INFESTATION,
Faulkner, L. R., and Bolander, W. J.
Washington State University, Prosser, Washington, Irrigated Agriculture Research and Extension Center.
Journal of Nematology, Vol. 2, No. 4, p 368-374, October 1970. 2 fig, 3 tab, 5 ref.

Descriptors: *Nematodes, *Irrigation water, *Water pollution sources, Irrigation wells, Aquatic animals, Entomology, Microbiology, Alfalfa, Beans, Sugarbeets, Wheat.

Water from a major irrigation canal and water from a deep well was used to irrigate plants growing in methyl bromide fumigated screenhouse ground beds. Nematode populations in these beds were compared during three seasons of continuous cropping to alfalfa, bean, eggplant, mint, sugarbeet, or wheat. Beds irrigated with canal water became heavily infested with a variety of plant parasitic nematodes while those receiving well water did not.

70-71:05B-027
A COMPUTER ANALYSIS ON THE LEACHING OF BORON FROM STRATIFIED SOIL COLUMNS,
Tanji, K. K.
California University, Davis.
Soil Science, Vol. 110, No. 1, p 44-51, July 1970. 3 fig, 3 tab, 15 ref.
(See 70-71:02G-063)

70-71:05B-028
MODEL THEORY FOR PREDICTING PROCESS OF LEACHING,
Alfaro, J. F., and Keller, J.
Utah State University, Logan, Utah.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 263-268, March 1970. 7 fig, 8 ref.
(See 70-71:02G-069)

70-71:05B-029
FARM NITRATES . . . NO MENACE TO THE RIO GRANDE,
Agricultural Research, United States Department of Agriculture, p 3-4, April 1970.

Descriptors: *Nitrates, *Water quality, Water pollution sources.

As part of a 30-year study of salt-balance conditions in three irrigated areas along the river, scientists obtained information about NO3-N content over a period of increasing use. Data indicates no significant stream pollution by NO3-N from nitrogen fertilizer. The greatly increased use of nitrogen fertilizer in the Rincon and Mesilla valleys has not increased the NO3-N load for the

Upper Rio-Grande. The rise in NO3-N at the El Paso-Hudspeth County line may be due in part to fertilizer, with most of the rise resulting from decreasing irrigation return flow and possibly treated sewage from the city of El Paso.

70-71:05B-030
PESTICIDES,
Metcalf, R. L.
Illinois University, Urbana, Illinois.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 57-60, March-April 1971. 1 fig, 2 tab, 12 ref.

Descriptors: *Water pollution sources, *Pesticides, *Agricultural chemicals, Water pollution, Pest control, Chemical wastes.
Identifiers: *Agricultural wastes.

The present use of pesticides is reviewed, with statistics given showing the important role pesticides play in agriculture. The agri-ecosystem, however, does not exist in vacuum; the effects on the quality of the total environment must be weighed. Presently, there is only superficial knowledge of effects of long term use of pesticides on the environment, and while they are microchemical pollutants, such micropollution is biologically significant as in the case of DDT in Lake Michigan and mercury levels in Lake Erie. Pesticides will remain indispensable in the foreseeable future, but should be controlled by prescription sale, supervision of use by trained plant pesticide control specialists or phytopharmacists, and by developing selective bio-degradable pesticides.

70-71:05B-031
SEDIMENT,
Robinson, A. R.
United States Department of Agriculture, Oxford, Mississippi, Sedimentation Laboratory.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 61-62, March-April 1971. 8 ref.

Descriptors: *Water pollution control, *Sediment control, *Erosion, Sediment transport, Sediment yield, Sediments, Sediment load, Sedimentation.
Identifiers: *Agricultural wastes.

Sediment depletes the land resources from which it is derived and impairs the quality of the water in which it is entrained and deposited. It is the nation's largest single water pollutant. Five aspects of sediment pollution are discussed: sediment properties; sediment yield; sediment transport; sediment deposition; and stream channel systems. The challenge is to reduce erosion; control the energy of stream flow; and create, where possible, nonerodiable stream boundaries.

70-71:05B-032
FERTILIZERS,
Viets, F. G., Jr.
United States Department of Agriculture, Fort Collins, Colorado, Agricultural Research Service, Northern Plains Branch, Soil and Water Conservation Research Division.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 51-53, March-April 1971. 1 tab, 18 ref.

Descriptors: *Water pollution sources, *Agricultural chemicals, Fertilization, Drainage effects, Environmental effects, Soil chemical properties, Leaching.
Identifiers: *Application rates, Fertilizer movement.

Fertilizers substantially reduce our land needs for crop production. To arbitrarily restrict fertilizer use therefore, would be a national disaster. Instead of exposing more land to erosion and the accompanying loss of nutrients, we should increase fertilizer rates on our better land and retire our poorer land to permanent grass or tree cover. What the fertilizer rates should be, depends on the crop, site conditions, and magnitude of nitrate leaching. These judgments can only be based on experience and research not on arbitrary rules and regulations.

70-71:05B-033
A PRIMER ON AGRICULTURAL POLLUTION,
Wadleigh, C. H.
United States Department of Agriculture, Beltsville, Maryland, Agricultural Research Service, Office of the Administrator.
In: Journal of Soil and Water Conservation, A Primer on Agricultural Pollution, Individual Papers, Vol. 26, No. 2, p 44-65, March-April 1971.

Descriptors: *Water pollution control, Animal wastes, Pesticides, Fertilizers, Irrigation, Sediments.
Identifiers: *Agricultural wastes.

Agriculture is asking itself some penetrating questions about its contribution to pollution: how much, in what manner, and what can be done to reduce the contribution." In an attempt to answer these and other questions, several prominent scientists review the current knowledge about the five major groups of pollutants generated by agriculture: animal wastes, fertilizers, irrigation residues, pesticides, and sediment. These assessments are introduced by an essay on the fundamental environmental quality issues of today, and summarized by one of the world's acknowledged experts on agricultural pollution.

70-71:05B-034
ANIMAL WASTES,
Webber, L. R.
Guelph University, Guelph, Onterio, Canada.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 47-50, March-April 1971. 2 fig, 21 ref.

Descriptors: *Water quality control, *Animal wastes, *Farm lagoons, Feed lots, Farm wastes, Oxidation lagoons, Waste disposal, Water pollution.

The demand for meat is continually increasing in North America. Thus the number of meat animals required is constantly increasing. This can and does cause problems related to waste disposal. Daily manure production amounts to 12 tons from 100,000 broilers, or 260 tons of solids plus 100 tons of liquid from 10,000 feeder cattle. This article discusses the various methods of waste disposal and the possible pollution problems associated with each. Research needs in this field are also discussed.

70-71:05B-035
ALLOCATION OF CATION EXCHANGE CAPACITY TO SOIL FRACTIONS IN SEVEN SURFACE SOILS FROM PANAMA,
Martini, J. A.
Institute Interamericano de Ciencias Agricolas de la OEA, Turrialba, Cost Rica.
Soil Science, Vol. 109, No. 5, p 324-331, May 1970. 1 fig, 6 tab, 19 ref.
(See 70-71:02G-072

70-71:05B-036
CONSERVATION OF SANDY SOILS WITH A SURFACE MULCH,
Fryrear, D. W., and Koshi, P. T.
United States Department of Agriculture, Big Springs, Texas, Agricultural Research Service.

American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3,
p 492-495, March 1971. 10 fig, 10 ref.
(See 70-71:04A-025)

70-71:05B-037
CROP RESIDUE DISPOSAL-TILAGE-PLANTING RELATIONSHIPS,
Colwick, R. F., Jones, J. W., and Fulgham, F. E.
United States Department of Agriculture, Agricultural Research Service, State College, Mississippi.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 1,
p 114-120, January 1971. 15 fig, 7 tab, 6 ref.
(See 70-71:02G-076)

70-71:05B-038
GRADED ROWS FOR THE CONTROL OF RILL EROSION,
Harris, W. S., and Watson, W. S., Jr.
Arkansas University, Fayetteville.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 3,
p 577-581, March 1971. 11 fig, 9 ref.
(See 70-71:04A-028)

70-71:05B-039
PREDICTION OF SEDIMENT YIELDS FROM SMALL WATERSHEDS,
Williams, J. R., Hiler, E. A., and Baird, R. W.
United States Department of Agriculture, Riesel, Texas.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 6,
p 1157-1162, June 1971. 5 fig, 5 tab, 19 ref.
(See 70-71:02E-009)

70-71:05B-040
QUALITY OF SURFACE IRRIGATION RUNOFF WATER,
Bondurant, J. A.
United States Department of Agriculture, Kimberly, Idaho, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 6,
p 1001-1003, June 1971. 1 tab, 7 ref.

Descriptors: *Irrigation practices, *Agricultural runoff, *Water pollution sources, Erosion, Soil conservation, Leaching, Water pollution.
Identifiers: *Fertilizer loss.

Chemical constituent concentrations increase in runoff waters during surface irrigation because of incorporation of undissolved fertilizer particles in the irrigation stream or by erosion of soil particles having attached fertilizer ions. Analysis of water applied to and runoff from a surface irrigation area near Paul, Idaho, shows only small changes in ion concentrations in runoff water as compared to applied water. More nutrient elements were applied to the field in the irrigation water than left in the runoff water. Losses of nitrate, phosphate, and sodium as a percent of the applied were approximately the same magnitude as the loss of water as runoff.

70-71:05B-041
SILT TRANSPORT BY THIN FILM FLOW,
Podmore, T. H., and Merva, G. E.
Queensland Institute of Technology, Toowoomba, Australia.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 6,
p 1065-1072, June 1971. 6 fig, 2 tab, 15 ref.
(See 70-71:02E-014)

70-71:05B-042
AIR AS A SOURCE OF LEAD IN EDIBLE CROPS,
Ter Haar, G.
Ethyl Corporation Research Laboratory, Ferndale, Michigan.
Environmental Science and Technology, Vol. 4, No. 3, p 226-230, March 1970.
1 fig, 5 tab, 15 ref.
(See 70-71:02I-015)

70-71:05B-043
RELATIONSHIP OF AUTOMOTIVE LEAD PARTICLES TO CERTAIN CONSUMER CROPS,
Schuck, E. A., and Locke, J. K.
California University, Riverside.
Environmental Science and Technology, Vol. 4, No. 4, p 324-330, April 1970.
4 fig, 9 tab, 8 ref.
(See 70-71:02I-016)

70-71:05B-044
NITROGEN FIXATION BY NONSYMBIOTIC MICROORGANISMS IN SOME CALIFORNIA SOILS,
Steyn, P. L., and Delwiche, C. C.
California University, Davis.
Environmental Science and Technology, Vol. 4, No. 12, p 1122-1128, December
1970. 2 fig, 5 tab, 32 ref.
(See 70-71:02G-083)

70-71:05B-045
CONTAMINATION OF ROADSIDE SOIL AND VEGETATION WITH CADMIUM, NICKEL, LEAD, AND ZINC,
Lagerwerff, J. V., and Specht, A. W.
United States Soils Laboratory, Beltsville, Maryland.
Environmental Science and Technology, Vol. 4, No. 7, p 583-586. July 1970.
2 tab, 36 ref.
(See 70-71:02I-017)

70-71:05B-046
LEAD CONTAMINATION OF SOME AGRICULTURAL SOILS IN WESTERN CANADA,
John, M. K.
Canada Department of Agriculture, Agassiz, British Columbia, Canada.
Environmental Science and Technology, Vol. 5, No. 12, p 1199-1203, December
1971. 1 fig, 4 tab, 15 ref.
(See 70-71:02I-018)

70-71:05B-047
GROUND WATER POLLUTION IN ARIZONA, CALIFORNIA, NEVADA, AND UTAH,
Fuhriman, Dean K., and Barton, James R.
Fuhriman, Barton & Associates, Provo, Utah.
Water Pollution Control Research Series 16060 ERU 12/71. 10 fig, 27 tab,
241 ref.

Descriptors: *Groundwater, *Water pollution, Groundwater basins, Water resources, Salinity.
Identifiers: *Southwest United States, Arizona, California, Nevada, Utah.

An investigation to determine the ground water pollution problems which exist in the states of Arizona, California, Nevada, and Utah was conducted. Data were obtained through an extensive review of the literature and through interviews with engineers, scientists, and governmental officials concerned with water pollution in the four states of the project area. Mineralization of groundwater is the most prevalent factor in the degradation of ground water quality in the project area. Large quantities of ground water in each of the four states are undesirable for many uses because of excessive mineralization. Much of the mineralization of ground water is a result of natural processes. Some is caused by man's activities--irrigation, oil field brine disposal, and over-pumping of aquifers are common causes of mineralization. Usually the degradation is caused by an excess of total dissolved solids, but at some locations, specific toxic substances are also found in the ground water. Of the various forms of pollution of ground water caused by man's activities, nitrate is probably most prevalent in the project area. A listing of conditions causing ground water pollution in the project area is included in the report.

70-71:05B-048
IRRIGATION RESIDUES,
Law, James P., Jr. and Witherow, Jack L.
Robert S. Kerr Water Research Center, Ada, Oklahoma, Environmental Protection Agency.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 54-56, March-April 1971. 13 ref.

Descriptors: *Irrigation effects, *Pollutants, Water quality control, Waste water, Pollution abatement.
Identifiers: *Agricultural pollution, Salinity control, Research needs.

The water quality problems associated with irrigation return flow are difficult to control. The major problems are the increased dissolved salt and nutrient content of waters draining from irrigated land. The difficulty in control is due to the diffuse nature of irrigation return flows coming from large irrigated areas and from both surface and subsurface drainage. Insufficient research has been devoted directly to the solution of return flow quality problems. Studies are needed to answer specific questions regarding both quantity and quality of irrigation residues. Possible control measures are discussed, but specific data concerning their effectiveness in abating water quality degradation are lacking. These must be evaluated and suitable management practices implemented to control water quality problems rising from irrigation.

70-71:05B-049
MOVEMENT OF AGRICULTURAL FERTILIZERS AND ORGANIC INSECTICIDES IN SURFACE RUNOFF,
Sievers, D. M., Lentz, G. L., and Beasley, R. P.
Missouri University, Columbia.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 323-325, March 1970. 6 fig, 1 tab, 7 ref.

Descriptors: *Water pollution sources, *Agricultural chemicals, *Nitrogen compounds, *Phosphorus compounds, *Chlorinated hydrocarbon pesticides, Translocation, Leaching, Fertilizers, Insecticides, Water pollution, Fishkill.

Three central Missouri soils were chosen with a wide range of physical properties. Six experimental plots, 45 3/4 in. square were established on each soil in fallow ground. To each plot was applied one of the following organic insecticides: heptachlor, aldrin, phorate, diazinon, carbaryl, and Bux Ten. All were applied in granular form by broadcasting at the rate of 17.1 lb. per acre. Ammonium nitrogen and superphosphate were applied in liquid form at the rate of 200 lb. N and 100 lb. P205 per acre. A sprinkling infiltrometer was used to apply simulated rainfall to the area and samples of the runoff were collected and analyzed. As was expected, the movement of fertilizers and insecticides is greatly influenced by the soil type.

70-71:05B-050
THE GEOCHEMISTRY OF UNDERGROUND WATER,
Swaine, D. J., and Schneider, J. L.

Division of Mineralogy, Sydney, Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971. Canberra, Australia, p 3-23. 7 fig, 2 tab, 45 ref.
(See 70-71:02F-060)

70-71:05B-051
SALINITY AND THE HYDROLOGIC CYCLE,
Holmes, J. W.
Flinders University, South Australia. School of Physical Sciences.
Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971. Canberra, Australia, p 25-40. 6 fig, 8 tab, 21 ref.
(See 70-71:02A-004)

70-71:05B-052
TRANSPORT OF SALTS IN UNSATURATED AND SATURATED SOILS,
Peck, A. J.
Division of Soils, Wembley, Western Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 109-123. 1 fig, 67 ref.
(See 70-71:02F-061)

70-71:05B-053
GROUNDWATER PROBLEMS OF THE INTERACTION OF SALINE AND FRESH WATER,
Wooding, R. A.
Commonwealth Scientific and Industrial Research Organization, Canberra, Australia, Division of Environmental Mechanics.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 125-139. 55 ref.
(See 70-71:01B-004)

70-71:05B-054
VARIABLES AFFECTING A-VALUES AS A MEASURE OF SOIL NITROGEN AVAILABILITY,
Broadbent, F. E.
California University, Davis.
Soil Science, Vol. 110, No. 1, p 19-23, July 1970. 3 fig, 4 tab, 15 ref.
(See 70-71:02G-052)

70-71:05B-055
CANALS OFFER VAST COOLING POTENTIAL,
Environmental Science and Technology, Vol. 4, No. 4, p 287, April 1970.

Descriptors: *Electric power production, *Electric powerplants, *Thermal pollution, Nuclear powerplants, Thermal powerplants, Water cooling.

As the need for more electrical power arises, the nation looks more to stream generation methods. The main drawback is how to handle the waste heat produced. One relatively new idea looks to canals as an answer. By using transportation, irrigation and water supply canals, a great heat sink is discovered. Strict controls would have to be followed, but the potential is enormous. The idea is still in the planning stages, but nonetheless is being considered.

70-71:05B-056
CONDUCTIVITY MEASUREMENTS MONITOR WASTE STREAMS,
Corrigan, P. A., Lyons, V. E., Barnes, G. D., and Hall, F. G.

Tennessee Valley Authority, Muscle Shoals, Alabama.
Environmental Science and Technology, Vol. 4, No. 2, p 116-121, February 1970.
4 fig, 1 tab.
(See 70-71:05A-007)

70-71:05B-057
AGRICULTURE POSES WASTE PROBLEMS,
Environmental Science and Technology, Vol. 4, No. 12, p 1098-1100, December 1970. 2 fig.

Descriptors: *Pollution abatement, Water pollution, Air pollution, Agricultural chemicals.
Identifiers: *Pollution sources, Agricultural pollution.

With the present massive agricultural production, the farmer is hard pressed to find adequate means for waste disposal. Commercial poultry, beef, and pork operations are all faced with the problem of wastes that contaminate air, water, and land. Increasing concentration and intensity of agricultural activities, necessary to the development and prosperity of the economy, are responsible for many new environmental issues. Some of the problem areas are: animal wastes, agricultural processing, domestic wastes, sediment from land, fertilizers, irrigation return flow, pesticides, aeroallergens, infectious agents, waste combustion, and natural plant emissions. Solutions include: drying, burying, waste treatment plants, erosion control, and controlled use of chemicals. The government is working towards programs that would reduce agricultural pollution.

70-71:05B-058
UNDERGROUND WASTE DISPOSAL: CONCEPTS AND MISCONCEPTIONS,
Caswell, C. A.
Gurnham and Associates, Incorporated, Chicago, Illinois.
Environmental Science and Technology, Vol. 4, No. 8, p 642-647, August 1970.
5 fig.

Descriptors: *Waste disposal wells, *Pollution abatement, Water pollution sources.

Underground disposal of wastes is booming into great popularity. However, it is not without its problems. This article points out many of the pros and cons of this popular practice. The approach of giving a general overview of the situation rather than the detailed mathematical study is taken. The process seems to work quite well for substances that are difficult to treat on the surface if the well is properly designed and operated. It should be kept in mind however that this method is not a cureall for pollution problems.

70-71:05B-059
NEED FOR CONTROLLING SALINITY OF THE COLORADO RIVER,
Colorado River Board of California.
Colorado River Board of California, Los Angeles, California, State of California.
Report, August 1970. 89 p. 10 fig, 12 tab, 32 ref, 1 append.
(See 70-71:05G-020)

70-71:05B-060
AGRICULTURAL POLLUTION OF THE GREAT LAKES BASIN,
United States and Canada.
U.S. Environmental Protection Agency, Water Quality Office.
Combined Report by Canada and the United States, 174 p. 15 fig, 42 tab, 22 ref, 4 append.
(See 70-71:05C-014)

70-71:05B-061
PERSISTENCE OF PESTICIDES IN RIVER WATER,
Eichelberger, James W., and Lichtenberg, James J.
Environmental Protection Agency, Cincinnati, Ohio. Water Quality Office.
Environmental Science Technology, Vol. 5, No. 6, p 541-544, 1971. 2 tab,
11 ref.

Descriptors: *Pesticides, *River, *Self-purification, Pesticide removal.
Identifiers: Azodrin, Baygon, BHC, Carbamate, Chlor, Chlorine, DDD, DDE, DDT,
Dieldrin, Endrin, Epoxide, Hepta, Organo, Phosphorus.

The persistence of 28 common pesticides in raw river water was studied over an 8-wk-period. Twelve organochlorine, 9 organophosphorus, and 7 carbamate pesticides were studied at a concentration of 10 microgram/l. No measurable degradation or chemical change was observed for the following organochlorine compounds: BHC, heptachlor epoxide, dieldrin, DDE, DDT, DDD, and endrin. Azodrin was the only organophosphorus compound that was stable throughout the study. All carbamate compounds were significantly changed after 1 wk, and all but Baygon were completely lost after 8 wk. Where possible, the degradation or chemical conversion products of the pesticides were identified.

SECTION XXII

WATER QUALITY MANAGEMENT AND PROTECTION

EFFECTS OF POLLUTION (Group 05C)

70-71:05C-001
ALTERNATIVES FOR SALINITY MANAGEMENT IN THE COLORADO RIVER BASIN,
Vincent, J. R., and Russell, J. D.
Federal Water Quality Administration, Denver, Colorado; and Federal Water Quality Administration, Alameda, California.
Paper 71076, Water Resources Bulletin, Vol. 7, No. 4, p 856-866, August 1971. 11 p, 10 fig, 3 tab.

Descriptors: *Salinity, *Water quality, *Economic impact, Water management (Applied), Cost comparisons, Costs, Dissolved solids, Damages, Water resources development.
Identifiers: Salt water disposal, *Colorado River Basin, Cost Curves, *Alternatives, Salt removal.

The Colorado River Basin faces the dilemma of an increasing demand for water while presently struggling with salinity concentrations approaching critical levels for some water uses. Based upon projected development, salinity concentrations are predicted to exceed 1200 mg/l at Imperial Dam by the yr 2010. Annual losses to the basin economy resulting from increased salinity will exceed $50 million by the yr 2010. Although methods of controlling salt discharged are relatively unrefined, certain conclusions, based upon Bayesian statistical methods, can be reached. Five basic alternatives for coping with the problem are evaluated. Total costs associated with any alternative, or the resulting salinity, are the sum of salinity detriments (cost to users for water of increased salinity plus economic multiplier effects) and the cost of constructing salt discharge control works. These impacts upon basin economy and Colorado River water quality for each alternative are presented.

70-71:05C-002
BIOLOCICAL EFFECTS ON SEDIMENT-WATER NUTRIENT INTERCHANGE,
Porcella, Donald B., Kumagai, James S., and Middlebrooks, E. Joe.
California University, Berkeley. Sanitary Engineering Research Lab; and Sunn, Low, Tom, and Hara, Inc., Honolulu, Hawaii.
American Society of Civil Engineers Proceedings, Journal of the Sanitary Engineering Division, Vol. 96, No. SA4, Paper 7460, p 911-926, August 1970. 5 fig, 8 tab, 10 ref.

Descriptors: *Nutrients, *Bottom sediments, *Limnology, *Algae, *Eutrophication, Lakes, Water quality, Phosphorus, Phosphates, Productivity, Leaching.
Identifiers: Sediment-water nutrient-exchange.

Different types of sediments vary in their ability to support algal growth. This is related to the amount of available phosphorus measured in the sediments. Although the amount of phosphorus released from the sediments varied with the type of sediment, all of the available phosphorus eventually should be extracted in the 15-cm layer of sediment studied. The development of a thick mat of Oscillatoria caused an increase in productivity due to the increased transfer of phosphorus from the sediment; and, in general, the more productive systems had sediments containing greater amounts of phosphorus. Also, the equilibration of P-32 with stable phosphate occurred more rapidly in the more productive systems, and this rate of equilibration appeared to be associated with the sediments themselves. Hence P-32 exchange with stable P was related to the concentration of available phosphorus in the system.

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70-71:05C-003
STUDIES RELATING TO WATER MINERALIZATION AND HEALTH,
Winton, Elliott F., and McCabe, Leland J.
Bureau of Water Hygiene, Cincinnati, Ohio.
Journal of American Water Works Association, Vol. 62, No. 1, p 26-30, January 1970. 5 p, 2 fig, 4 tab, 36 ref.

Descriptors: *Water quality, *Public health, *Human diseases, *Human pathology, *Hardness (Water), Mortality, Trace elements, Calcium, Magnesium, Chemical properties, Water softening.
Identifiers: Heat disease-water quality relations.

Recent studies on the relation of heart disease to water quality are reviewed. Correlation is sufficient to suggest more definitive studies to resolve the question. Calcium, magnesium, and total hardness contents of drinking water seem to be inversely correlated with coronary heart disease death rates in England, the United States, and Asian countries. Several specific questions are listed for experimental and statistical investigation.

70-71:05C-004
CHEMISTRY OF NITROGEN AND PHOSPHORUS IN WATER,
McCarty, P. L.
Journal American Water Works Association, Vol. 62, No. 2, p 127-140, February 1970. 14 p, 6 fig, 8 tab, 64 ref.

Descriptors: *Nutrients, *Eutrophication, *Water quality control, *Nitrogen compounds, *Phorphorus compounds, Algae, Nutrient requirements, Productivity, Essential nutrients, Water quality, Water chemistry, Cycling nutrients.
Identifiers: Nitrogen requirements (Algae), Phosphorus requirements (Algae), Nutrient chemistry (Aquatic).

Of the major elements essential to algal growth, nitrogen and phosphorus are the ones most likely to be of critically limiting availability in natural waters. Because they therefore represent promising weak links in algal life cycles, their chemical states and behavior in water are examined to see how water treatment might benefit. Large supplies of nitrogen and phosphorus are present in many bodies of water either in the sediments, the atmosphere above, or in the form of dissolved gas. These forms may be available for the growth of algae and other aquatic plants, but the rates at which they may become available is slow. These rates are important, however, as they tend to control the amount of vegetative growth which can be supported. Soluble nitrogen and phosphorus contained in the effluents from waste treatment plants, on the other hand, are in a readily available form. If discharged to natural bodies of water, they can stimulate growth far in excess of that which would occur naturally.

70-71:05C-005
EFFECT OF SOLID WASTE DISPOSAL ON GROUNDWATER QUALITY,
Coe, Jack J.
California State Department of Water Resources, Los Angeles, Southern District.
Journal of American Water Works Association, Vol. 62, No. 12, p 776-783, December 1970. 8 p, 9 fig, 5 tab, 12 ref.

Descriptors: *Landfills, *California, *Water pollution sources, Path of pollutants, Water pollution control, Carbon dioxide, Organic matter, Water quality, Groundwater movement, Waste disposal, Biodegradation.
Identifiers: Sanitary landfills.

Municipal solid wastes are produced in California at a rate of about 7 lb/per capita per day. Most of this waste is disposed of in sanitary landfills. Gas movement rates were found to be 0.22 to 0.8 ft per day vertically and 0.24 to 1.4 ft per day horizontally in undisturbed alluvial soils. Groundwater is often impaired by refuse decomposition products whenever water is allowed to pass through the decomposed material in such quantities as to eventually reach the groundwaters of the area. Leachate impairment of groundwater causes temporary increases in organic material and permanent increases in mineral constituents. Impairment is typified by increases in total dissolved solids, total hardness, chloride, and sulfate. Such increases may last several years. Carbon dioxide effects on groundwater are increases in hardness and bicarbonate. Depending on the pH after carbon dioxide adsorption, water may become corrosive. By modifying a site--usually by the construction of a physical barrier--the groundwater can be protected.

70-71:05C-006
A REVIEW OF LITERATURE ON INORGANIC NITROGEN METABOLISM IN MICROORGANISMS,
Painter, H. A.
Water Pollution Research Laboratory, Stevenage (England).
Water Research, Vol. 4, P 393-450, 1970. 276 ref.

Descriptors: *Microorganisms, *Metabolism, *Nitrogen compounds, *Reviews, *Bibliographies, Nitrogen cycle, Inhibition, Growth rates, Nitrogen, Microbiology, Water pollution effects.
Identifiers: Autotrophs, Heterotrophs.

All biological growth processes require nitrogen in some form or other for the synthesis of cellular proteins and nucleic acids. Microorganisms can utilize a range of nitrogen compounds for these syntheses. A review of the literature on microbiological changes involving inorganic nitrogen was undertaken and the known essential characteristics of the identifiable processes have been listed. The nutritional requirements, especially for oxygen, of the organisms involved have been described in detail, as have methods for inhibition. Quantitative kinetic and energy data have been included. Suggested pathways and mechanisms are described only where they indicate possible intermediates that can be found in natural habitats. Events involving inorganic nitrogen in purification processes have been described and discussed in light of what is known about various nitrogen transformations considered in isolation. The review revealed a complex situation which can be used only as a guide as to which changes involving nitrogen will occur in a given situation. There are still gaps in the knowledge of the processes. Suggestions are put forward for further investigations.

70-71:05C-007
INFLUENCE OF SOIL SALINITY ON PRODUCTION OF DRY MATTER AND UPTAKE AND DISTRIBUTION OF NUTRIENTS IN BARLEY AND CORN: I. BARLEY (HORDEUM VULGARE L.)
Hassan, N. A. K., Drew, J. V., Knudsen, D., and Olson, R. A.
Agricultural Experiment Station, Abu-Ghraib, Iraq, Soils Department.
Agronomy Journal, Vol. 62, No. 1, p 43-45, 1970. 2 tab, 1 fig, 10 ref.

Descriptors: *Soil salinity, Barley, Corn, Saline soils.
Identifiers: Nutrient distribution, dry matter production, barley (Hordeum vulgare L.)

The production of dry matter and the uptake and concentration of nutrients by barley (Hordeum vulgare L.) from soil adjusted to different levels of salinity with a mixture of salts were evaluated in a greenhouse study. Following germination of the plants, soil salinity levels ranging from EC values of 0 to 30 mmhos/cm of the soil solution at field capacity were induced by additions of a salt solution containing one part Na_2SO_4, one part $MgSO_4$, and one part $CaCl_2$. During the growth period of 98 days, increasing soil salinity increased sulfate-S and chloride in the saturation extract and lowered soil pH. Exchangeable Na, Mg, and Ca increased markedly while exchangeable K and available P increased only slightly. Acid-extractable Mn increased, but there was little or no effect on acid-extractable Zn, Fe, and Cu. Production of dry matter by the vegetative parts and grain heads of barley increased up to an EC of 12, then decreased at salinity levels above this value. Coefficients of correlation indicate significant negative relationships between soil salinity and uptake of P, K, Ca, Fe, and Cu by the vegetative parts and grain heads of barley.

Conversely, significant positive correlations occur between soil salinity and uptake of Mn and Na by barley.

70-71:05C-008
A SURVEY OF THE PRINCIPLES OF METALLIC CORROSION AND ITS CONTROL IN SALINE WATERS,
Denholm, W. T., and Potter, E. C.
Commonwealth Scientific and Industrial Research Organization, Grand City, Victoria, Australia, Division of Mineral Chemistry.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 61-78. 4 fig, 19 ref.
(See 70-71:05G-022)

70-71:05C-009
CHEMISTRY OF SALINE SOILS AND THEIR PHYSICAL PROPERTIES,
Quirk, J. P.
University of Western Australia, Institute of Agriculture, Dept of Soil Science and Plant Nutrition.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 79-91. 2 fig, 1 tab, 32 ref.
(See 70-71:02G-086)

70-71:05C-010
HYDROLOGY OF SWELLING SOILS,
Philip, J. R.
Division of Environmental Mechanics, Canberra, Australia, Commonwealth Scientific and Industrial Research Organization.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 95-107. 7 fig, 23 ref.
(See 70-71:02G-087)

70-71:05C-011
SALINITY AND ANIMAL CELLS,
Gage, P. W.
South Wales University, Kensington, Australia, School of Physiology and Pharmacology.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 179-191. 4 fig, 10 ref.
(See 70-71:02K-041)

70-71:05C-012
SALINITY AND THE WHOLE PLANT,
Robinson, J. B.
University of Adelaide, South Australia, Dept of Agriculture.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 193-206. 1 fig, 3 tab, 42 ref.
(See 70-71:02K-042)

70-71:05C-013
SALINITY AND PLANT CELLS,
Campbell, L. C., and Pitman, M. G.
Sydney University, New South Wales, Australia, School of Biological Sciences.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 207-224. 6 fig, 3 tab, 45 ref.
(See 70-71:02K-043)

70-71:05C-014
AGRICULTURAL POLLUTION OF THE GREAT LAKES BASIN,
United States and Canada.
U.S. Environmental Protection Agency, Water Qualtiy Office.
Combined Report by Canada and the United States. 174 p. 15 fig, 42 tab, 22 ref,
4 append.

Descriptors: *Pollution abatement, *Water pollution, *Water pollution effects,
*Water pollution sources.
Identifiers: Great Lakes Basin, Agricultural pollution.

This report is a state-of-the Art document concerning abatement of pollution of the Great Lakes Basin, as specifically influenced by agricultural and related sources. It primarily relates to the identification of the impact of agricultural and related activities on the pollution of the Great Lakes Basin. The major constituents of these non-point sources of pollution which were studied include: 1) runoff and release of nutrients, pesticides, and herbicides and degradation by-products as a consequence of the application of agricultural chemicals; 2) runoff of pollutants from animal waste management structures and land used for ultimate disposal; 3) sedimentation resulting from current land use practices, including land influenced by agricultural activities and by local, state and federal activities on public lands, highways, and parks. Also under study was the scope of current planning, advisory and regulatory functions of the United States and Canadian Governments.

70-71:05C-015
THE MINERAL QUALITY PROBLEM IN THE COLORADO RIVER BASIN,
Regions VIII and IX, U.S. Environmental Protection Agency.
United States Environmental Protection Agency.
Report, Regions VIII and IX, 1971. 9 fig, 9 tab, 4 append.

Descriptors: *Salinity, *Water quality, *Irrigation effects, Irrigation,
Irrigation water, Water pollution control, Return flow.
Identifiers: Mineral quality, Colorado River Basin, Salinity studies,
Salinity control.

The Colorado River Basin Water Quality Control Project was established as a result of recommendations made at the first session of a joint Federal-State "Conference in the Matter of Pollution of the Interstate Waters of the Colorado River and Its Tributaries" held in 1960. This project serves as the technical arm of the conference and provides the conferees with detailed information on water uses, the nature and extent of pollution problems and their effects on water users, and recommended measures for control of pollution in the Colorado River Basin. In 1963, the Colorado River Basin Water Quality Control Project began detailed studies of the mineral quality problem in the Colorado River Basin in 1963. The more significant findings and data from the project's salinity studies are summarized in the report entitled "The Mineral Quality Problem in the Colorado River Basin." Detailed information pertaining to the methodology and findings of the project's salinity studies are presented in three appendices to that report--Appendix A, "Natural and Man-made Conditions Affecting Mineral Quality;" Appendix B, "Physical and Economic Impacts;" and Appendix C, "Salinity Control and Management Aspects."

70-71:05C-016
FISH AND POWER PLANTS,
Jensen, Albert C.
New York State Department of Conservation, Albany. Division of Marine and
Coastal Resources.
The Conservationist, New York State Conservation Department, Vol. 24, No. 3,
p 2-5, December 1969-January 1970. 4 p, 2 fig, 2 photo.

Descriptors: *Hudson River, *Estuarine environment, *Pumped storage, Hydroelectric plants, Water temperature, Fish, Ecology, Aquatic habitats,

Environmental effects, Fisheries, New York.
Identifiers: Hudson River Estuary, Storm King Mountain, Cornwall (New York).

A biological survey was made to predict the effects of the proposed Storm King Mountain pumped storage hydroelectric plant on the ecology of the Hudson River Estuary. Large numbers of eggs, larvae, and young striped bass would be withdrawn by the proposed hydroelectric plant. However, the eggs and young fish that would be withdrawn would be but a small percentage of the total number of each of the life stages of striped bass present in the estuary. Approximately 2.8% would be subject to withdrawal. Substantial numbers of blueback herring, alewife, tomcod and white perch, small enough to pass through the screens, also would be withdrawn seasonally but that because of the varying distribution of the species in the estuary, the effect of losses by the operation of the plant probably would be minimal. Operation of additional plants--power, manufacturing or other--that require large volumes of water could, in combination with the proposed Cornwall plant, destroy sufficient numbers of eggs and larvae of fishes to adversely affect subsequent populations. These effects could be particularly severe if the plants were built in areas of heavy fish concentrations. The proposed pump-storage hydroelectric plant at Cornwall would not have a significant adverse effect on the populations of striped bass and shad in the Hudson River.

70-71:05C-017
SALINITY AND THE WHOLE ANIMAL,
Macfarlane, W. V.
University of Adelaide, South Australia, Waite Agricultural Research Institute.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 161-178. 2 fig, 4 tab, 62 ref.
(See 70-71:02K-040)

SECTION XXIII

WATER QUALITY MANAGEMENT AND PROTECTION

WASTE TREATMENT PROCESSES (Group 05D)

70-71:05D-001
EVALUATION OF ANAEROBIC DENITRIFICATION,
Seidel, D. F., and Crites, R. W.
Metcalf and Eddy, Incorporated, Palo Alto, California.
Journal of the Sanitary Engineering Division, Proceeding of the American Society of Civil Engineers, Vol. 96, No. SA 2, p 267-277, April 1970. 7 fig, 1 tab, 8 ref.

Descriptors: *Anaerobic digestion, *Denitrification, *Filters, Pilot plants, Laboratory test, Anaerobic bacteria, Nitrates, Waste water treatment, Sewage treatment, Waste treatment.
Identifiers: Upflow, Horizontal flow, Media.

Several methods of removing nitrogen from sewage effluents by anaerobic denitrification were evaluated. An upflow anaerobic filter containing gravel media (1 in. to 1.5 in.) was used to denitrify a municipal wastewater which contained an average of 14 mg/l nitrate nitrogen. Results obtained from pilot plant studies using methanol as a supplementary carbon source for the denitrifying bacteria showed 90% nitrogen removal with a detention time as short as 1.5 hours. Laboratory studies were also conducted utilizing upflow and horizontal flow filters containing a fiber media composed of a Dynel fiber coated with neoprene resin and bonded to a fiberglass mesh. This highly porous fiber media performed comparably to the gravel media in the upflow filter as 88% nitrate nitrogen removal was obtained with a detention time of 2 hours. However, media configuration and poor flow distribution limited the success of the horizontal flow filters. Several advantages of the anaerobic filter process for denitrification such as, low initial and operating cost, simplicity of operation, long solids retention times, and absence of any sludge recycle or disposal equipment were presented. The cost of methanol was the major operating expense for the process. The quantity of methanol required increases with increasing dissolved oxygen and nitrate nitrogen and decreasing effluent BOD. The total cost not including the cost of nitrifying the secondary effluent was estimated as low as $12.00 per million gallons.

70-71:05D-002
HYDROLOGY OF SPRAY-RUNOFF WASTE WATER TREATMENT,
Thomas, Richard E., Law, James P., Jr., and Harlin, Curtis C., Jr.
Robert S. Kerr Water Research Center, Ada, Oklahoma.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 96, No. IR3, Paper 7538, p 289-298, September 1970. 10 p, 4 fig, 4 tab, 15 ref.

Descriptors: *Waste water disposal, *Soil disposal fields, *Overland flow, *Runoff, *Sprinkler irrigation, Evaporation, Evapotranspiration, Water balance, Hydrologic budget, Sewage treatment, Soil water movement, Waste treatment.
Identifiers: Spray-runoff waste water treatment.

Liquid measuring procedures used in a 12-month study of the hydrology of the soil treatment system at Campbell Soup Company's Paris, Texas plant accounted for 93% of the total liquid applied to the soil. The rainfall and waste water applied to the soil system are accounted for as follows: 18% is lost to the atmosphere through evaporative processes; 61% is recovered as runoff; and 21% percolates through the soil. The fraction of the treated waste water recovered as runoff ranges from a low of 30% to a high of 85%. This range in the percent runoff is influenced by climate, soil textural class, and waste water spray schedules. Waste water spray schedules are controlled to partially offset variations in the percent runoff which would normally occur as the result of climatic influences.

70-71:05D-003
RECLAIMED WASTE WATER FOR GROUNDWATER RECHARGE,
Baier, D. C., and Wesner, G. M.
California State Water Resources Control Board, Sacramento.
Water Resources Bulletin, Vol. 7, No. 5, p 991-1001, October 1971. 2 fig, 6 tab, 5 ref.

Descriptors: *Water reuse, *Groundwater recharge, *Tertiary treatment, *Reclaimed water, *California, Water quality, Odor, Taste, Artificial recharge, Injection wells.
Identifiers: Trickling filters.

Reclaimed trickling filter effluent is injectable and does not cause excessive well clogging. Multi-casing injection wells performed very satisfactorily. The reclaimed water would be acceptable for domestic use after travel through 500 feet of a confined aquifer in that bacteria, virus and toxic material were consistently absent, but the odor, taste, and high concentrations of dissolved inorganics are undesirable characteristics. Methods to eliminate the odor are being tested.

70-71:05D-004
A STUDY OF WASTEWATER IRRIGATION THROUGH COMPUTER SIMULATION,
Cypra, Kenneth J., Cowlishaw, Wayne, and Bauer, William J.
Bauer Engineering, Incorporated, Chicago, Illinois.
Water Resources Bulletin, Vol. 6, No. 6, p 935-943, November-December 1970. 9 p, 4 fig, 2 tab, 3 ref.

Descriptors: *Simulation analysis, *Water reuse, *Waste water disposal, *Irrigation water, Sewage effluents, Michigan, Mathematical models, Systems analysis, Computer programs, Water storage, Waste treatment, Lagoons.
Identifiers: *Wastewater irrigation, *Muskegon (Michigan).

Muskegon, Michigan, typical of a medium-sized Northern urban area, is currently adopting wastewater irrigation to meet its present and future wastewater treatment needs. Design of a system for Muskegon, Michigan must consider, among other things, the quantity of storage needed prior to irrigation and the quality of water in the storage lagoons. A computer-simulated operation of the storage and irrigation aspects of the proposed wastewater irrigation system resulted in a better understanding of storage requirements and critical quality parameters (particularly anaerobic conditions during spring break-up). Results are depicted in terms of maximum storage requirements and in terms of average monthly outflow. Maximum storage requirements occur in April and May before the start-up of spring irrigation. Maximum wastewater irrigation occurs April to July with the peak varying according to the irrigation rate. Quality values are generally independent of the rates of irrigation. The BOD level within the storage logoons is estimated to range from about 12 to 43 mg/liter, with DO levels ranging from 0 to about 8 mg/liter. The simulation program is written in FORTRAN IV for acceptance by the GE Mark I series computer.

70-71:05D-005
GROUNDWATER RECHARGE DESIGN FOR RENOVATING WASTE WATER,
Bouwer, Herman.
Agricultural Research Service, Phoenix, Arizona. Water Conservation Laboratory.
American Society of Civil Engineers Proceedings, Journal Sanitary Engineering Division, Vol. 95, No. SA1, Paper 7096, p 59-74, February 1970. 16 p, 10 fig, 1 tab, 20 ref.

Descriptors: *Artificial recharge, *Water spreading, *Water reuse, *Tertiary treatment, Infiltration, Filtration, Sewage treatment, Sewage disposal, Hydrogeology, Groundwater movement, Water resources development, Reclaimed water.
Identifiers: Phoenix (Arizona), Salt River (Arizona).

Soil and hydrogeologic conditions permitting, groundwater recharge by surface spreading is an economic and esthetic way for further treatment or renovation of secondary sewage effluent, cannery wastes, or similar low-quality water. The design of a system of spreading areas with wells or drains for collecting the reclaimed water should generally be based on: (1) A maximum limit for the elevation of the water table mound beneath the spreading areas; (2) a minimum limit for the underground detention time and travel distance as the water moves to the wells or drains; and (3) minimum contamination of the groundwater in the aquifer outside the recharge system. Hydraulic properties of aquifers, including anisotropy, can be determined by analog and by field measurements. These data are used to evaluate the effective transmissibility for recharge, and to calculate water-table positions and underground detention times for a system of long, parallel spreading strips with wells midway between the strips.

70-71:05D-006

DENITRIFICATION BY ANAEROBIC FILTERS AND PONDS - PHASE II

Jones, James R.
Water Quality Office, Environmental Protection Agency, Washington, D. C.
Bio-Engineering Aspect of Agricultural Drainage, Report No. 13030 ELY 06/71-14, June 1971. 34 p, 12 fig, 4 tab, 6 ref.

Descriptors: *Agricultural wastes, *Denitrification, *Irrigation water, Return flows, Nitrate, Anaerobic treatment.
Identifiers: *San Joaquin Valley, California, Bacterial denitrification, Anaerobic filters, Anaerobic ponds.

Operational criteria, design and operations costs for a treatment facility to remove nitrogen from agricultural tile drainage in the San Joaquin Valley were further investigated during 1970 at the Interagency Agricultural Wastewater Treatment Center near Firebaugh, California. The year-long study period is identified as Phase II. Based on projected nitrate-nitrogen concentrations for valley tile drainage water, the research in this phase extended earlier Phase I studies on the feasibility of bacterial denitrification by filters and covered ponds. The anaerobic filter with 1-inch rounded aggregate was capable of reducing influent nitrate-nitrogen from 30 mg/l to 2 mg/l at water temperatures from 12^{0} to 16^{0}C at a 6-hour detention time, and from 15 mg/l to 2 mg/l at water temperatures of 20^{0} to 24^{0}C at 1-hour detention time. Long-term operation of filters resulted in accumulation of bacterial mass which caused the deterioration of the hydraulic regime and nitrogen removal efficiencies. Air scour accompanied or followed by flushing with water was capable of controlling the bacterial mass. The consumptive ratio, a method to quantify the organic carbon source needed for anaerobic bacterial process, was affected by temperature and influent nitrogen concentration and was found to vary between approximately 1.2 and 2.4. The anaerobic covered pond reduced influent nitrate-nitrogen from 30 mg/l to 2 mg/l at water temperatures of 12^{0} to 16^{0}C with a 60-day detention time and from 15 mg/l to 2 mg/l at 20^{0} to 2-^{0}C with a 10-day detention time.

70-71:05D-007

DENITRIFICATION BY ANAEROBIC FILTERS AND PONDS,

Sword, Bryan R.
Environmental Protection Agency, Office of Research and Monitoring, Robert S. Kerr Water Research Center, Ada, Oklahoma.
Bio-Engineering Aspects of Agricultural Drainage, Report No. 13030 ELY 04/71-8, April 1971. 68 p, 20 fig, 18 tab, 36 ref.

Descriptors: *Agricultural wastes, *Denitrification, *Irrigation water, *Return flows, *Nitrate, *Anaerobic treatment.
Identifiers: *San Joaquin Valley, California, Bacterial denitrification, Anaerobic filters, Anaerobic ponds.

The removal of nitrogen from tile drainage by means of bacterial reduction was investigated at the Interagency Wastewater Treatment Center near Firebaugh, California. The major nitrogen form in tile drainage is nitrate (approx. 98%). The process required that an organic carbon source be added to the waste to accomplish reduction of the nitrogen. The bacterial process was used in two configurations; anaerobic filters and anaerobic deep ponds. It was found that with the addition of 65 mg/l of methanol, 20 mg/l nitrate-nitrogen could be reduced to 2 mg/l or less of total nitrogen within one hour of treatment by filter denitrification at water temperatures as low as 14°C. The same removal was achieved at 12°C in a filter operating at a detention time of two hours. A covered deep pond required an actual detention time of eight days at water temperatures of approximately 22°C and a theoretical detention time of 15 days at temperatures of approximately 16°C to accomplish the same removal. An uncovered pond was not able to achieve the same results at theoretical detention times as long as 20 days. The projected costs for both processes are approximately $90 per million gallons.

70-71:05D-008
DESALINATION OF AGRICULTURAL TILE DRAINAGE
Sword, Bryan R.
Water Quality Office, Environmental Protection Agency, Washington, D.C.
Agricultural Wastewater Studies, 13030 ELY 05/71-12, May 1971. 32 p, 13 fig, 6 tab, 6 ref.

Descriptors: *Desalination, *Irrigation waters, *Return flow, Reverse osmosis, Electrodialysis, Salinity, Nitrate, Boron, Tile drains.
Identifiers: *San Joaquin Valley (California).

Investigations were made to determine the technical feasibility of desalination of tile drainage. The source of the tile drainage was a 400-acre field near Firebaugh, California. Reserse Osmosis (RO) and Electrodialysis (ED) processes were studied. Two RO membrane stacks were investigated. The first, a high salt rejection, low product yield, was operated on variable quality (3000-7000 mg/l TDS) irrigation return water. In the 7-month investigation period TDS removal efficiencies decreased from 93 percent to 80 percent salt rejection and the product flux decreased from 12 gal/ft^2/day to less than 9 gal/ft^2/day. The 20 mg/l of nitrate-nitrogen and 8 mg/l of boron contained in the influent were not effectively rejected. The second RO stack and also the ED unit were operated on return waters that were controlled to have a 3000 gm/l TDS. The second RO stack was designed for a high product rate and low salt rejection. The TDS removal remained at 85 percent for a 3-month run. Product flux decreased from over 19 gal/ft^2/day to less than 12 gal/ft^2/day. Nitrate and boron rejection was low. The ED data are based on a single pass through the membrane stack. The TDS removal varied from 35 percent to 15 percent. The nitrate removal rate was greater than the TDS removal. Boron removal was negligible. It is estimated that the costs for the two processes are approximately equal--$320 per million gallons of product.

70-71:05D-009
NITRATE REMOVAL FROM WASTE WATERS BY ION EXCHANGE,
Grinstead, Robert R., and Jones, Kenneth C.
Dow Chemical U.S.A., Walnut Creek, California, Western Division Research Laboratories.
Water Pollution Control Research Series, 17010 FSJ 01/71, January 1971. 99 p, 13 fig, 15 tab, 50 ref.

Descriptors: *Nitrates, *Denitrification, *Anion exchange, Waste water treatment, Municipal wastes, Water pollution treatment, Resins, Tertiary treatment, Solvent extractions.
Identifiers: Amidines.

This report described an exploratory experimental study of the use of porous polymer beads containing a water-immiscible extractant system for the removal of nitrate from waste waters. Alkylated amidines proved to be a suitable class of compounds for the extractant system. They are relatively strong bases, and exist in the salt form in contact with waste waters in the pH range of 7-8. They can, however, be readily regenerated with alkalis, such as ammonia or sodium hydroxide. The amidinium ion in the organic phase selectively extracts nitrate ion over chloride ion by a factor of about 20 (i.e., the nitrate/chloride ratio in the organic phase is about 20 times the ratio in the equilibrium aqueous phase), and nitrate over sulfate and bicarbonate by much higher ratios. From typical municipal waste waters amidine systems will therefore pick up mainly the nitrate ion. Amidines dissolved in an aromatic hydrocarbon were absorbed in macroporous polystyrene beads and used to treat a synthetic municipal waste water containing 62 ppm nitrate ion and 350 ppm chloride ion. Beds of this material treated up to 70 bed volumes of water prior to breakthrough of the nitrate in the effluent. The absorbed nitrate ion was removed with either ammonia or sodium hydroxide.

70-71:05D-010
REMOVAL OF NITRATE BY AN ALGAL SYSTEM,
Brown, Randall L.
Department of Water Resources, Fresno, California, San Joaquin District.
Agricultural Wastewater Studies, 13030 ELY 4/71-7, April 1971. 132 p, 58 fig, 27 tab, 59 ref.

Descriptors: *Agricultural wastes, *Water pollution control, Biological treatment, Nitrates, Treatment facilities.
Identifiers: *Algae stripping, Scenedesmus, Algal growth and harvesting.

An algal system consisting of algae growth, harvesting and disposal was evaluated as a possible means of removing nitrate-nitrogen from subsurface agricultural drainage in the San Joaquin Valley of California. The study of this assimilatory nitrogen removal process was initiated to determine optimum conditions for growth of the algal biomass, seasonal variations in assimilation rates, and methods of harvesting and disposal of the algal product. A secondary objective of the study was to obtain preliminary cost estimates and process design. The growth studies showed that about 75 to 90 percent of the 20 mg/l influent nitrogen was assimilated by shallow (12-inch culture depth) algal cultures receiving 2 to 3 mg/l additional iron and phosphorus and a mixture of 5 percent CO_2. Theoretical hydraulic detention times required for these assimilation rates varied from 5 to 16 days, depending on the time of the year. The total nitrogen removal by the algal system, assuming 95 percent removal of the algal cells, ranged from 70 to 85 percent of the influent nitrogen. The most economical and effective algal harvesting system tested was flocculation and sedimentation followed by filtration of the sediment. The algal cake from the vacuum filter, containing about 20 percent solids, was then air- or flash-dried to about 90 percent solids. The market value for this product as a protein supplement was estimated to be about $80 to $100 per ton.

70-71:05D-011
REMOVAL OF NITROGEN FROM TILE DRAINAGE - A SUMMARY REPORT,
Brown, Randall L.
Department of Water Resources, Fresno, California, San Joaquin District; and Water Quality Office, San Francisco, California, Environmental Protection Agency, Pacific Southwest Region.
Agricultural Wastewater Studies, 13030 ELY 7/71, DWR Bulletin 174-9, July 1971. 28 p, 6 fig, 2 tab, 6 ref.

Descriptors: *Agricultural wastes, *Water pollution control, Biological treatment, Nitrates, Treatment facilities.
Identifiers: *Algal growth and harvesting, *Bacterial denitrification, Desalination, Nitrogen removal.

Studies by an interagency group have shown that it is technically feasible to reduce 20 mg/l nitrate-nitrogen in agricultural tile drainage to 2-5 mg/l by either algae stripping or bacterial denitrification. Conditions necessary for maximum algal growth included 8- to 12-inch pond depth, addition of small amounts of nutrients (CO_2, Fe, and P), up to four hours of daily mixing and detention times of from 5 to 16 days, depending on the season. The algae were harvested by coagulation-sedimentation followed by vacuum filtration. Bacterial denitrification was tested in anaerobic deep ponds and filters using methanol as a carbon source. Required detention times were on the order of 8 to 50 days for covered ponds (uncovered ponds were not suitable) and 1 to 2 hours for filters. During long-term operation of the filters periodic flushing was required to remove accumulated bacterial biomass. Preliminary cost estimates were $90 and $135 per million gallons for bacterial denitrification (either pond or filter) and algae stripping respectively. Laboratory studies indicated that nitrogen removal effectively lowered the biostrimulatory nature of the waste with respect to algal growth in potential receiving waters. Two desalination processes were also studied--electrodialysis and reverse osmosis. Both processes effectively reduced total dissolved solids but neither removed boron, or reduced nitrate to the desired level.

70-71:05D-012
TECHNIQUES TO REDUCE NITROGEN IN DRAINAGE EFFLUENT DURING TRANSPORT,
Williford, John W., and Cardon, Doyle R.
Department of Interior, Fresno, California, Bureau of Reclamation, Fresno Field Division,
Agricultural Wastewater Studies, 13030 ELY 6/71-10, June 1971. 48 p, 7 fig, 11 tab, 14 ref.

Descriptors: *Waste water treatment, *Nitrates, *Denitrification, *Agricultural waste, Algae, Anaerobic bacteria, Dissolved oxygen, Dissolved solids, Cost analyses.
Identifiers: *San Luis drain (California), *Kesterson reservoir, *Nitrogen reduction, Detention times.

Three methods to remove nitrates from the agricultural drainage water from the San Luis Service Area were investigated. One method was a theoretical evaluation of nitrate removal by algae during the transport of the drainage water in the San Luis Canal or during storage in the Kesterson Reservoir. The other methods were designed to promote anaerobic bacterial denitrification in a continuous flow of drainage water. One method used barley straw and the other water grass grown in shallow ponds as the carbon energy source. The barley straw was placed in a trench about 10 feet deep and the nitrate removal rate determined under various flow and detention rates. The water grass was grown in ponds under a continuous flow of water of about 4 to 6 inches depth. Under optimum conditions both methods reduced the nitrate -N concentration of the drainage water from a maximum of about 30 mg/l to less than 2 mg/l. The cost of nitrogen removal by the shallow grass plot systems, the most economical and feasible method investigated, was estimated to be $6.50 per acre foot or $20.00 per million gallons.

70-71:05D-013
THE EFFECTS OF AGRICULTURAL WASTE WATER TREATMENT ON ALGAL BIOASSAY RESPONSE,
Tunzi, Milton G.
Environmental Protection Agency, San Francisco, California, Region IX, Water Quality Office.
Agricultural Waste Water Studies, 13030 ELY 8/71-0, August 1971. 59 p, 8 fig, 14 tab, 9 ref.

Descriptors: *Eutrophication, *Bioassay, *Denitrification, *Fluorometry, *Tile drains, Nitrates, Nitrogen.
Identifiers: *Algal blooms - control, Bioassay - algal, Chlorophyll, Denitrification, Fluorometry, Tile drainage.

Laboratory bioassay experiments were performed to test the effect on algal growth of agricultural waste water before and after the waste water had been subjected to two different nitrogen removal processes. The waste waters were added in various percentages to San Joaquin River Delta water for bioassay. The algal growth throughout time was monitored by chlorophyll fluorescence techniques. The fluorescence measurements showed logarithmic growth similar to the type usually observed in the Delta Water over the vernal growth period. The laboratory experiments gave positive statistical evidence that the untreated agricultural waste water would promote substantial algal growth above that of the San Joaquin River controls. Both nitrogen removal processes were equally effective in lowering the algal growth to that of the Delta water controls as long as the nitrate-nitrogen level in each removal system had been lowered to approximately 2 mg N/l, or less.

70-71:05D-014
AGRICULTURE POSES WASTE PROBLEMS,
Environmental Science and Technology, Vol. 4, No. 12, p 1098-1100, December 1970. 2 fig.
(See 70-71:05B-057)

70-71:05D-015
UNDERGROUND WASTE DISPOSAL: CONCEPTS AND MISCONCEPTIONS,
Caswell, C. A.
Gurnham and Associates, Incorporated, Chicago, Illinois.
Environmental Science and Technology, Vol. 4, No. 8, p 642-647, August 1970. 5 fig.
(See 70-71:05B-058)

70-71:05D-016
THE SOIL AS A RESOURCE RENOVATOR,
Evans, J. O.
United States Department of Agriculture, Washington, D. C.
Environmental Science and Technology, Vol. 4, No. 9, p 732-735, September 1970. 3 fig, 6 ref.

Descriptors: *Waste disposal, *Waste treatment, Sewage disposal, Sanitary engineering, Municipal wastes, Organic wastes, Sewage, Water pollution.

The use of surface soil as a source of disposing organic waste materials is explored. Not only cultivated land but also range and forested areas should be considered. A challenge for qualified personnel to reach the possibilities and develop further criteria is sounded.

SECTION XXIV

WATER QUALITY MANAGEMENT AND PROTECTION

ULTIMATE DISPOSAL OF WASTES (Group 05E)

70-71:05E-001
EFFECT OF METHOD OF MANURE HANDLING ON CROP YIELDS, NUTRIENT RECOVERY AND RUN-OFF LOSSES,
Hensler, R. R., Olsen, R. J., Witzel, S. A., Attoe, O. J., and Paulson, W. H.
Wisconsin University, Madison, Dept of Agricultural Engineering; and Wisconsin University, Madison, Dept of Soils.
Transactions of the American Society of Agricultural Engineers, Vol. 13, No. 6, p 726-731, November-December 1970. 10 tab, 26 ref.

Descriptors: *Farm wastes, *Crop production, *Application methods, Runoff, Nutrients, Greenhouses, Waste disposal, Chemical analysis, Fertility, Soil chemical properties.
Identifiers: *Nutrient recovery, Anaerobic liquid manure, Aerobic liquid manure.

A study was made of the effect of type of manure, method of handling, amount of bedding, drying treatment, and rate of application on the fertilizing value of cattle manure for corn and hay and on runoff losses. Dairy and beef cattle manure was applied as fresh, fermented, aerobic liquid and anaerobic liquid, both in greenhouse conditions and in actual field tests. Tests were run to determine nutrient loss before application and nutrient recovery by plants and runoff losses after application. Results showed increased corn dry matter in all cases of manure application with poorer results shown by the aerobic liquid than the other three. Allowing manure to dry for one week before incorporation usually gave lower yields and lower recovery values for N, P, and K. Total dry-matter yields of corn were not greatly affected by increasing amounts of bedding up to 8 percent, but at the 16 percent rate, yields were usually much lower.

70-71:05E-002
UNDERGROUND WASTE DISPOSAL: CONCEPTS AND MISCONCEPTIONS,
Caswell, C. A.
Gurnham and Associates, Incorporated, Chicago, Illinois.
Environmental Science and Technology, Vol. 4, Np. 8, p 642-647, August 1970. 5 fig.
(See 70-71:05B-058)

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SECTION XXV

WATER QUALITY MANAGEMENT AND PROTECTION

WATER TREATMENT AND QUALITY ALTERATION (Group 05F)

70-71:05F-001
FIELD TECHNIQUES FOR REMOVING NITRATES FROM DRAINAGE WATER,
Williford, John W., McKeag, John A., and Johnston, William R.
Bureau of Reclamation, Fresno, California. Westlands Water District.
Transactions of the American Society of Agricultural Engineers, p 167-171, 1971.
5 fig, 4 tab, 7 ref.

Descriptors: *Irrigation water, *Drainage water, *Nitrates, Agriculture, Denitrification, Costs, Water purification, Separation techniques, California.
Identifiers: San Luis Drain (California), San Luis Wasteway (California), Deep trench technique, Barley straw cover, Water grass plots.

A 3.3 day detention of drainage water in a deep trench filled with barley straw reduced nitrate concentration of agricultural drainage water from 35 to less than 2 ppm. A 2 day detention of drainage water in a shallow grass plot reduced nitrate content from 70 to less than 10 ppm. The cost of treatments per acre-foot of drainage water containing 70 ppm of nitrate was estimated between $1.50 and $1.90.

70-71:05F-002
SENSORY EXAMINATION OF MINERALIZED, CHLORINATED WATERS,
Pangborn, R. M., Baldwin, R. E., and Trabue, I. M.
California University, Davis. Dept of Food Science and Technology.
Journal of the American Water Works Association, Vol. 62, No. 8, p 572-576,
September 1970. 6 fig, 1 tab, 7 ref.

Descriptors: *Water purification, *Chlorine, *Mineral waters, *Taste, Odor, Calcium, Sodium, Magnesium, Chloride, Carbonate, Sulfate, Laboratory tests, Temperature.
Identifiers: Sensory tests.

Water taste is affected by its mineralization and the form that mineralization takes, such as chloride, sulfate, and carbonate. An extensive research program has been undertaken to measure consumer acceptance of high mineral waters with the introduction of chlorine as an added stimuli. The data collected indicate that the characteristic taste of chlorine in solution can be modified considerably by the specific dissolved minerals in the water. Although results from relatively simple, model systems used herein would be somewhat different in a natural drinking water containing a wider variety of dissolved minerals, as well as organic matter, the data provide an insight on the interactive effects of solution temperature and chlorine concentration.

70-71:05F-003
NITRATE IN DRINKING WATER,
Winton, E. F., Tardiff, R. G., and McCabe, L. J.
Bureau of Water Hygiene, Cincinnati, Ohio.
Journal of American Water Works Association, Vol. 63, No. 2, p 95-98, February
1971. 2 fig, 5 tab, 18 ref.

Descriptors: *Water treatment, *Water quality, *Public health, *Nitrate, *Diseases, *Water quality standards, Standards.

The adequacy of the present public health specification for the nitrate content of drinking water was reviewed. Results are not definitive, but it appears that the present recommended nitrate limit provides a valid margin of safety when the water is used for infants and may offer the respectable safety-factor needed to cover all reasonable situations. A final decision awaits the results of

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further research. Warnings on the water bill or the supply of an alternate source of water for infant feeding can only be viewed as undesirable, although necessary, temporary measures, where supplies contain more nitrate than the standard. Energies should be directed to developing economic nitrate-removal processes and to preventing further nitrate pollution.

70-71:05F-004
MINERAL TASTE AND THE POTABILITY OF DOMESTIC WATER,
Bruvold, W. H.
California University, Berkeley.
Water Research, Vol. 4, p 331-340, November 1969. 2 fig, 10 tab, 10 ref.

Descriptors: *Domestic water, *Potable water, *Taste, Water quality, Water quality control, Standards, California.
Identifiers: *Mineral taste, Taste quality, Mineral content.

The relation between mineral content and the general taste quality of water is described. Consumers from 11 selected California communities evaluated the taste of the local water by completing specially constructed attitude scales. Taste panel members evaluated the taste of the same 11 waters using specially constructed rating scales. Total mineral content in the water ranged from 50 to 2250 mg/l. Results from both consumer and panel work showed an inverse linear relation between taste quality and total mineral content. The implications of these results for establishing standards limiting mineral content in domestic water were discussed.

70-71:05F-005
THE SOIL AS A RESOURCE RENOVATOR,
Evans, J. O.
United States Department of Agriculture, Washington, D. C.
Environmental Science and Technology, Vol. 4, No. 9, p 732-735, September 1970.
3 fig, 6 ref.
(See 70-71:05D-016)

70-71:05F-006
THE MINERAL QUALITY PROBLEM IN THE COLORADO RIVER BASIN,
Regions VIII and IX, U.S. Environmental Protection Agency.
United States Environmental Protection Agency.
Report, Regions VIII and IX, 1971. 9 fig, 9 tab, 4 append.
(See 70-71:05C-015)

SECTION XXVI

WATER QUALITY MANAGEMENT AND PROTECTION

WATER QUALITY CONTROL (Group 05G)

70-71:05G-001
DRAIN INSTALLATION FOR NITRATE REDUCTION,
Willardson, L. S., Meek, B. D., Grass, L. B., Dickey, G. L., and Bailey, J. W.
Agricultural Research Service, Brawley, California, Southwestern Irrigation Field Station; Soil Conservation Service, Fresno, California; and Bureau of Reclamation, Sacramento, California, Land Resources Branch.
Groundwater, Vol. 8, No. 4, p 11-13, July-August 1970. 3 p, 2 fig, 2 tab, 2 ref.

Descriptors: *Denitrification, *Biodegradation, *Nitrates, *Groundwater, *Drainage systems, Subsurface drainage, Drawdown, Water level fluctuations, Saturated flow, Unsaturated flow, Aeration.
Identifiers: Groundwater denitrification.

A field experiment was installed near Firebaugh in the San Joaquin Valley of California to test submerged drains as a means of denitrification of groundwater. Laboratory and field experiments show that denitrification occurs in saturated soil where there is ample organic carbon available for bacterial metabolism. Denitrification and dilution of high nitrate groundwater were accomplished in the field study.

70-71:05G-002
SURFACE WATER QUALITY IS INFLUENCED BY AGRICULTURAL PRACTICES,
Holt, R. F.
Agricultural Research Service, Morris, Minnesota.
Paper No. 71-740, Presented at the 1971 Winter Meeting of the American Society of Agricultural Engineers, Chicago, Illinois, December 7-10, 1971. 3 tab, 34 ref.
(See 70-71:05B-024)

70-71:05G-003
ADSORPTION AND TRANSPORT OF AGRICULTURAL CHEMICALS IN WATERSHEDS,
Frere, M. H.
Agricultural Research Service, Durant, Oklahoma, United States Department of Agriculture-SWC.
Oral Paper, presented at the 1971 Winter Meeting American Society of Agricultural Engineers, Chicago, Illinois, December 7-10, 1971. 1 fig, 12 ref.
(See 70-71:05B-025)

70-71:05G-004
SOIL - WATER RELATIONSHIP,
Irrigation Journal.
Irrigation Journal, Vol. 21, No. 5, p 6-9, September-October, 1971. 2 fig, 3 tab.
(See 70-71:03F-044)

70-71:05G-005
BOLD NEW DEVELOPMENT FOR IRRIGATION,
Bureau of Reclamation.
Reclamation Era, Vol. 56, No. 1, p 15-18, February 1970. 3 fig.
(See 70-71:03F-045)

70-71:05G-006
STARTING WITH TRICKLE IRRIGATION,
DeRemer, E. D.
Business Dynamics Corporation, Phoenix, Arizona.
Reclamation Era, Vol. 56, No. 4, p 15-17, November 1970.
(See 70-71:03C-009)

70-71:-5G-007
IRRIGATION GUESSWORK - GOODBYE,
Cassai, N.
United States Bureau of Reclamation, Region 7, Denver, Colorado, Information Officer.
Reclamation Era, Vol. 56, No. 2, p 16-18, May 1970. 2 fig.
(See 70-71:03F-047)

70-71:05G-008
TRICKLE IRRIGATION. . . A MORE EFFICIENT MEANS OF WATER MANAGEMENT,
Lyons, C. G., Jr.
Texas Agricultural Extension Service, Welasco, Texas.
Texas Agricultural Progres, Vol. 18, No. 1, p 3-4, Winter 1972. 5 fig.
(See 70-71:03C-010)

70-71:05G-009
MODEL THEORY FOR PREDICTING PROCESS OF LEACHING,
Alfaro, J. F., Keller, J.
Utah State University, Logan, Utah.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 263-268, March 1970. 7 fig, 8 ref.
(See 70-71:02G-069)

70-71.05G-010
CALIFORNIA DRIP-IRRIGATION TESTS MAY PROVE METHOD SIGNIFICANT,
Irrigation Journal.
Irrigation Journal, Vol. 21, No. 2, p 12-13, March-April 1971.
(See 70-71:03C-011)

70-71:05G-011
NEW FINDINGS ON THE USE OF TRICKLE IRRIGATION SYSTEMS IN THE UNITED STATES, AUSTRALIA & ISRAEL,
DeRemer, E. D.
Business Dynamics Corporation, Phoenix, Arizona.
World Irrigation, Vol. 20, No. 6, p 14-16, December 1970. 4 fig, 1 tab.
(See 70-71:03C-012)

70-71:05G-012
HOW TO RECYCLE RUNOFF,
Coleman, C.
World Irrigation, Vol. 10, No. 3, p 20-24, April 1970. 2 fig.
(See 70-71:03F-054)

70-71:05G-013
THEORY OF CHEMICAL TRANSPORT WITH SIMULTANEOUS SORPTION IN A WATER SATURATED POROUS MEDIUM,
Lindstrom, F. T., and Boersma, L.
Orgeon State University, Corvallis, Dept of Agricultural Chemistry and Soils.
Soil Science, Vol. 110, No. 1, p 1-7, July 1970. 7 tab, 16 ref.
(See 70-71:02F-055)

70-71:05G-014
NATIONAL IRRIGATION RETURN FLOW RESEARCH AND DEVELOPMENT PROGRAM,
Law, James P., Jr.
Robert S. Kerr Water Research Center, Ada, Oklahoma, Environmental Protection Agency, Treatment and Control Research, Agricultural Wastes.
Report 13030WRV12/71, Environmental Protection Agency, Washington, D. C., 1971.
23 p, 2 fig, 11 ref.

Descriptors: *Water quality control, *Irrigation effects, Pollution abatement, Waste water.
Identifiers: *National research program, *Irrigation return flow, Control measures, Agricultural waste water.

The status of the National Irrigation Return Flow Research and Development Program is presented. Current research projects and future program development are discussed. The report represents the position of the Environmental Protection Agency (EPA) with regard to the development of effective controls on the quality of irrigation return flows. Program goals and milestones are outlined. A number of potential control measures are discussed. Improvements in the water delivery system, on-the-farm water management, and the water removal system are considered with respect to improving the quality of irrigation return flows and decreasing the degradation of receiving waters. Research and investigations are needed to evaluate the effectiveness of potential control measures. Demonstrations and educational activities will be required to overcome institutional, political, and legal constraints to water management reform.

70-71:05G-015
RESEARCH NEEDS FOR IRRIGATION RETURN FLOW QUALITY CONTROL,
Skogerboe, G. V., and Law, J, P., Jr.
Colorado State University, Fort Collins, Agricultural Engineering Department.
Report 13030---11/71, Environmental Protection Agency, Washington, D. C., 1971.
98 p, 9 fig, 9 tab, 31 ref.

Descriptors: *Water pollution effects, *Water pollution sources, *Water quality control, Fertilizers, Irrigation water, Nematodes, Nitrates, Phosphates, Salinity.
Identifiers: *Return flow, Irrigated land, Irrigated systems.

There are a multitude of research needs regarding irrigation return flow quality, but only the specific research needs required to undertake an effective control program are described. These research needs include irrigation practices, soil-plant-salinity relationships, leaching requirements, prediction of subsurface return flow, cultural practices, irrigation scheduling, treatment of return flows, economic evaluations, and institutional control methods.

70-71:05G-016
GET DOUBLE USE OUT OF IRRIGATION WATER,
Bondurant, J. A.
United States Department of Agriculture, Kimberly, Idaho. Agricultural Research Service, Snake River Conservation Research Center.
Idaho Farmer, Vol. 88, No. 6, p 24-27, March 1970.
(See 70-71:03F-065)

70-71:05G-017
RETURNED PROFITS,
Irrigation Age, Vol. 4, No. 9, p 20-21, April 1970. 8 fig.
(See 70-71:03F-069)

70-71:05G-018
SALT RIVER PROJECT'S COMPUTERIZED IRRIGATION,
World Irrigation, Vol. 20, No. 6, p 17, December 1970. 1 fig.
(See 70-71:03F-070)

70-71:05G-019
CONDUCTIVITY MEASUREMENTS MONITOR WASTE STREAMS,
Corrigan, P. A., Lyons, V. E., Barnes, G. D., and Hall, F. G.
Tennessee Valley Authority, Muscle Shoals, Alabama.
Environmental Science and Technology, Vol. 4, No. 2, p 116-121, February 1970.
4 fig, 1 tab.
(See 70-71:05A-007)

70-71:05G-020
NEED FOR CONTROLLING SALINITY OF THE COLORADO RIVER,
Colorado River Board of California.
Colorado River Board of California, Los Angeles, California.
Report, August 1970. 89 p, 10 fig, 12 tab, 32 ref, 1 append.

Descriptors: *Salinity, *Irrigation water, *Water quality, Saline water, Irrigation effects, Return flow, Irrigation, Water pollution.
Identifiers: Colorado River, California.

This report presents the results of an appraisal of sources of salinity of the Colorado River, probable increases in the river's salinity that will occur in the future, deterious impact that such increases will have on California's users of Colorado River water, possible measures for controlling the river's salinity, and recommendations for actions that, if effected, would tend to keep the river's salinity from increasing above its present high levels.

70-71:05G-021
IRRIGATION RESIDUES,
Law, James P., Jr., and Witherow, Jack L.
Robert S. Kerr Water Research Center, Ada, Oklahoma, Environmental Protection Agency.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 54-56, March-April 1971. 13 ref.
(See 70-71:05B-048)

70-71:05G-022
A SURVEY OF THE PRINCIPLES OF METALLIC CORROSION AND ITS CONTROL IN SALINE WATERS,
Denholm, W. T., and Potter, E. C.
Commonwealth Scientific and Industrial Research Organization, Grand City, Victoria, Australia, Division of Mineral Chemistry.
In: Salinity and Water Use, 2nd National Symposium on Hydrology, November 2-4, 1971, Canberra, Australia, p 61-78. 4 fig, 19 ref.

Descriptors: *Water quality, *Salinity, *Corrosion, Chemical reactions, Electrolysis, Metallurgy, Oxidation, Saline water, Water pollution effects, Well casings.

An outline of the theory of corrosion processes is presented, using pH-potential diagrams to summarize theoretical and experimental data relating to corrosion; the pitting corrosion of iron in chloride-containing waters is treated in some detail. The complicating effects of the many factors which influence corrosion behaviour in practical cases are discussed and the more common methods of corrosion control explained. It is emphasized that catalogued information relating to corrosion behaviour must be interpreted with caution; and if possible, should be supplemented with the accumulated experience and judgment of specialists in the field.

SECTION XXVII

WATER RESOURCES PLANNING

TECHNIQUES OF PLANNING (Group 06A)

70-71:06A-001
A MATHEMATICAL MODEL FOR EVALUATING THE POTENTIAL OF DESALTING,
Rothermel, T. W., Sachs, M. S., and O'Shaughnessy, F.
Little (Arthur D.), Incorporated, Cambridge, Massachusetts; and Office of Saline Water, Washington, D.C.
Water Resources Bulletin, Journal of the American Water Resources Association, Vol. 7, No. 4, p 867-877, August 1971. 4 fig.

Descriptors: *Desalination, *Computer models, *Forecasting, *Water supply, *Comparative costs, Water demand, Brackish water, Flash distillation, Reverse osmosis, Long-tube vertical distillation, Electrodialysis.

The Office of Saline Water has recognized the need for a mathematical model to forecast the future potential of desalting. Future applications of desalting will evolve from the needs of (1) augmentation of conventional sources in critical water years, (2) arid parts of the Southwest, (3) water quality improvements, (4) isolated communities, and (5) highly water-efficient agriculture. Desalting will increasingly be called upon to maintain the water supply-demand balance. Modeling is the best way to analyze desalting potential in view of the uncertainties involved in water supply due to political, legal and economic considerations. A dynamic simulation model has been developed by Arthur D. Little, Inc. to translate the determinants of water demand and supply into a forecast of desalting potential. The model projects needs for desalting in 20 hydrologic regions of the U.S. Current results indicate potential desalting capacities of 225 MGD in 1980, 2,250 MGD in 2000, and 7,000 MGD in 2020. Improvements in desalting economics will increase these potentials four to five times by the 2000-2020 period. Model inputs and results are continuing to be refined. Preliminary results indicate the models' ability to produce instinctive forecasts and to evaluate the role of desalting under various future conditions.

70-71:06A-002
IRRIGATION PLANNING 2: CHOOSING OPTIMAL AVERAGES WITHIN A SEASON,
Dudley, N. J. Howell, D. T., and Musgrave, W. F.
Montana State University, Bozeman, Dept of Economics and Agricultural Economics.
Water Resources Research, Vol. 7, No. 5, p 1051-1063, October 1971. 6 fig, 1 tab, 8 ref.

Descriptors: *Optimization, *Simulation analysis, *Dynamic programming, *Linear programming, *Least squares method, *Irrigation, *Soil-water-plant relationships, Estimating, Economic efficiency.

A simulation-dynamic programming model designed to give optimal solutions to the intermediate-run irrigation problem of selecting the best combination of irrigation and dryland acreages to plant in any season in which the beginning-season reservoir contents are at a particular level was presented. A simple crop growth simulation model was used over a number of years on a large acreage subject to stochastic reservoir inflows and stochastic crop water demand. The model was applied to a hypothetical problem and actual stream-flow data and reservoir characteristics were used. An optimality-approximating technique was developed. Irrigation decision rules at each of a number of decision points were taken from the output of the dynamic programming model used to solve the short-run problem. The results showed that the best acreage to plant is an approximately linear function of the beginning-season reservoir level. This function is highly sensitive to changes in profitability of the alternative dryland crop. Further, using the least squares method it was found that the cost of planting suboptimal acreages was high. A major limitation of the approach used was its failure to allow a portion of the crop to go temporarily unirrigated. Also, it did not allow for reinstatement during the season.

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70-71:06A-003
OPTIMAL INTRASEASONAL IRRIGATION WATER ALLOCATION,
Dudley, N. J., Howell, D. T., and Musgrave, W. F.
Montana State University, Bozeman, Dept of Economics and Agricultural Economics.
Water Resources Research, Vol. 7, No. 4, p 770-789, August 1971. 7 fig, 3 tab, 14 ref.

Descriptors: *Optimum development plans, *Irrigation programs, *Water allocation (Policy), *Computer models, *Risks, *Dynamic programming, *Soil-water-plant relationships, Simulation analysis, Climatic data.
Identifiers: *Bellman.

A plant growth-soil moisture simulation model was incorporated into a two state variable stochastic dynamic programming model to determine the optimal intraseasonal allocation pattern for irrigation water in an uncertain environment. The decision variable used in the dynamic programming model was the level of available soil water content before irrigation. The two state variables were soil water content and irrigation reservoir level per acre of irrigated crop. Historical traces of climatic data were used. Several earlier models were discussed. This study's unique feature was its incorporation of environment uncertainty in its approach to the problem of optimal allocation of a fixed water supply over the irrigation season. Given the initial assumed relationships within the model, the study results suggest that an irrigator should maintain available soil moisture in the root zone at a high level, even if it means early exhaustion of the water supply. The limitations and assumptions of the soil moisture-plant growth model and the dynamic programming model were explicitly recognized.

70-71:06A-004
LINEAR PROGRAMMING MODELS FOR ESTIMATING THE AGRICULTURAL DEMAND FUNCTION FOR IMPORTED WATER IN THE PECOS RIVER BASIN,
Gisser, Micha.
New Mexico University, Albuquerque.
Water Resources Research, Vol. 6, No. 4, p 1025-1032, August 1970. 1 fig, 4 tab, 13 ref.

Descriptors: *Water allocation (Policy), *Water demand, *Crop production, *Linear programming.
Identifiers: *Pecos River Basin, Miller's theorem.

This paper provides the results of applying parametric linear programming methods to estimate the agricultural demand function for imported water in the Pecos Basin. A parametric linear programming model suitable for the Pecos Basin is developed. Agricultural activities in which land is irrigated either by local or imported water and either ditch or sprinkler irrigation are developed and adjusted for forecasted 1980 prices. These agricultural activities are used by the parametric linear programming model, and various agricultural demand functions are obtained for the Pecos Basin. These functions show the expected quantities of imported irrigation water that would be demanded at different prices and under a variety of constraints.

70-71:06A-005
QUASILINEARIZATION AND THE IDENTIFICATION OF AQUIFER PARAMETERS,
Yeh, William W-G., and Tauxe, George W.
California University, Los Angeles, Dept of Engineering Systems.
Water Resources Research, Vol. 7, No. 2, p 375-381, April 1971. 7 p, 2 fig, 3 tab, 10 ref. California University Water Resources Center Project W290.

Descriptors: *Parametric hydrology, *Linear programming, *Mathematical models, *Aquifer characteristics, Simulation analysis, Computer programs, Storage coefficient, Transmissivity, Confined water, Systems analysis, Data processing.
Identifiers: Quasilinearization.

A new computational procedure based on observations at observation wells is presented to solve the problem of identifying aquifer parameters. This new procedure (quasilinearization), is an effective way to convert the observations directly to aquifer parameters. The procedure is advantageous because it involves neither curve plotting nor graphical matching. It makes full use of the ability of the modern high speed digital computer to integrate a system of ordinary differential equations with given initial conditions. The parameters to be identified are the storage coefficient and transmissivity in a confined aquifer system.

70-71:06A-006
SOME EXPERIENCE ON THE USE OF THE GEOPHYSICAL METHODS WHEN CONDUCTING RECLAMATION STUDIES,
Sharapahov, N. N., Chernyak, G. Y., and Makagonova, S. K.
The All-Union Research Institute of Hydrogeology and Engineering Geology, USSR.
International Commission of Irrigation and Drainage Bulletin, July 1971.
1 tab, 4 fig.

Descriptors: Geological surveys, Investigations.
Identifiers: Soviet Union, Reclamation studies, Geophysical methods.

The geophysical methods can help in providing quantitative evaluation of a series of figures necessary when preparing special engineering and geological maps aimed at reclamation development of arid lands. The experience of the workers of the Institute obtained in the Chu River Valley and other regions (particularly in the Dnepropetrovsk District of the Ukrainian SSR) has shown that the maximum positive effect is achieved when different geophysical investigation methods are combined, i.e., VES and VES EP and seismic prospecting by refracted waves with impact excitation of elastic vibrations. This complex should be closely connected with the landscape studies over the entire area under survey and should be accompanied by the common engineering-geological and hydrogeological studies that envisage carrying out the mining and drilling works at a thinner scheme.

SECTION XXVIII

WATER RESOURCES PLANNING

EVALUATION PROCESS (Group 06B)

70-71:06B-001
A METHOD FOR INCORPORATING AGRICULTURAL RISK INTO A WATER RESOURCE SYSTEM PLANNING MODEL,
Conner, J. R., Freund, R. J., and Godwin, M. R.
Florida University, Gainsville; and Texas A and M University, College Station.
Water Resources Bulletin, Vol. 7, No. 3, p 506-516, June 1971. 4 fig, 3 tab, 22 ref.

Descriptors: *Water resources development, *Planning, *Risks, *Model studies, Mathematical models, Analytic techniques, Methodology, Simulation analysis, Irrigation.
Identifiers: *Water resources systems, *Agricultural risk, Risk programming.

Prior studies of water resource systems have considered risk from the point of view that only the system planners could react to the effects of the risk elements. However, users of water from a system also react to risk. When the quantity of water that a system can supply is subject to considerable variation, the reactions of the users of the water will often effect the benefits generated by the system and thus its optimal design characteristics. A simulation model of a reservoir-irrigation system is developed which incorporates the water users' reactions to risk in such a manner as to reflect their influence on the optimal design characteristics. A risk (convex) programming algorithm is incorporated into the model to reflect the water users' reactions to various levels of aversion to risk and degree of uncertainty in water deliveries. Response surfaces are generated as a result of performing the simulation at different levels of the design variables. An examination of these surfaces reveals the importance of including water users' reactions to risk in water resource planning. The effects of different levels of risk aversion on the irrigation farmers' choice of crop enterprises are also examined.

70-71:06B-002
LAND USE FUNCTION IN WATER QUALITY MANAGEMENT,
Howells, David H.
North Carolina Water Resources Research Institute, Raleigh.
Water Resources Bulletin, Vol. 7, No. 1, p 162-170, February 1971. 17 ref.

Descriptors: *Land use, *Water quality, *Water quality control, Water policy, Land management, Water pollution control, Standards, Regulation, Runoff.
Identifiers: *Water quality management, *Land use policy, Land use control.

The Nation has entered a new era of water quality management in which land use policy and regulation must assume an increasingly important role. The benefits of tertiary and advanced waste treatment may be offset by contradictory land use and pollution from land runoff. Unless land use planning and controls are included in water quality management, land-imposed constraints on water quality can be anticipated. Pollution from major types of land runoff are reviewed with respect to sources, effects, and control procedures. Emphasis is given to land use practices and controls. The crucial issue with regard to the latter is lack of land use policies at federal, state, and local levels. State legislation establishing guidelines and minimum standards for land use regulation by local government is required. The dependency of water quality on land use points to the fallacy of attempting to provide for comprehensive water pollution control outside the context of comprehensive land-water resources planning and management.

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SECTION XXIX

WATER RESOURCES PLANNING

COST ALLOCATION, COST SHARING, PRICING/REPAYMENT (Group 06C)

70-71:06C-001
A NEW FOCUS IN WATER SUPPLY ECONOMICS - URBAN WATER PRICING,
Mann, Patrick C.
West Virginia University, Morgantown, College of Commerce.
Journal American Water Works Association, Vol. 62, No. 9, p 534-537, September 1970. 1 tab.

Descriptors: *Water rates, *Water costs, *Pricing, Use rates, Rates, Public utilities, Cost analysis, Marketing, Economics, Utilities.
Identifiers: *Rate structures, *Water rate analysis, Principal component analysis.

The rapid growth of urban areas and the increasing scarcity of water supplies have created a need for an economic analysis of urban water pricing. This paper discusses existing water rate structures, the methods by which they are determined, and problems which are encountered in their use. A statistical analysis of urban water prices is also presented. The technique of principal component analysis was used to analyze six measures of urban water price. These included the monthly metered rates for 500 cu ft, 1000 cu ft, 10,000 cu ft, 100,000 cu ft of water, the water revenue per million gallons produced, and the water revenue produced per million gallons sold. Principal component analysis is a statistical factor analysis which determines general patterns of association among variables on the basis of their intercorrelations. For the 113 water utilities examined by this method it was shown that the above six measures were 'relatively highly interrelated,' and were a general price index for these utilities. The results also indicated a strong association between the monthly metered rate for 100,000 cubic feet, and the water revenues per million gallons sold. A further investigation showed that the 25 utilities having the lowest water prices were located near large bodies of water, and the 25 utilities having the highest prices were privately owned.

70-71:06C-002
UTILITY WATER RATE STRUCTURING,
Banker, R. F., and Benson, R. B.
Black and Veatch, Kansas City, Missouri.
Journal of the American Water Works Association, Vol. 63, No. 4, p 203-205, April 1971. 1 fig, 1 ref.

Descriptors: *Utilities, *Water rates, *Structures, Economics, Costs, Cost sharing, Pricing, Financing, Scheduling, Planning.
Identifiers: Implementation, Customer, Equity, Service costs, Block rates, Demand commodity rates, Billing.

From a review of recent rate studies, there appears to be no end in sight to the overall upward spiral of water-utility costs and the consequent periodic need of an upward adjustment of rates. The vast majority of water utilities will have to face the problem of convincing an increasingly sensitive public of the necessity for larger and more frequent increases in the price of water. The customer must be convinced that he is being treated in a reasonable and fair manner, and that he is only paying his fair share of the water costs. From the perspective, cost of service, form of rate structure, number of schedules, design of block rates, service charges, demand-commodity rates, outside-city rates, and billing frequency are discussed. Water rates should be adequate in order to return necessary revenue that will allow the utility to meet all of its financial obligations. The rate schedule should be designed to recover, to the extent practicable, the costs of providing service to each of the customer classes and to be acceptable to the individual customer as well. As long as these two key factors are properly recognized, the utility can work

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toward the implementation of new rates with the assurance that it is acting with equity and fairness and in the best interests of its customers.

70-71:06C-003
RATE PHILOSOPHY,
Hyle, R. C.
Portland Water Bureau, Oregon.
Journal of the American Water Works Association, Vol. 63, No. 11, Part 1, p 682-687, 1971. 0 fig, 0 tab, 0 ref.

Descriptors: *Water demand, *Water supply, *Costs, *Equitable apportionment, Use rates, Forecasting, Management.

Water rates tend to change slowly in response to changes in other parts of the economy; this lag may be due to political constraints as well as to the factors affecting demand and supply. In the long run, the industry may be under little economic pressure to increase rates. The high rate of investment per dollar of revenue means that fixed costs underlie a large part of the price charges. If the utility is growing, the decline in average fixed costs tends to offset increases in operating costs; if debt is retired, the relief from debt service may more than compensate for other cost increases. In practice, water rates tend to be such that the water users provide the revenue needed to keep the utility solvent. While revenue bonds now constitute virtually all major financing, it is still the water customer who pays. In theory, water users should pay for only a portion of the capital construction. Some construction and replacement costs should be met from general tax funds, for instance. Furthermore, main extensions and other improvements supplied to a limited area should be financed chiefly by those directly benefited.

SECTION XXX

WATER RESOURCES PLANNING

WATER DEMAND (Group 06D)

70-71:06D-001
HIGH PLAINS IRRIGATION AND TEXAS WATER PLAN,
Wells, D. M.
Texas Technological College, Lubbock.
Journal of the Irrigation and Drainage Division, American Society of Civil Engineers, Vol. 97, No. IR1, p 123-130, March 1971. 4 tab, 7 ref.

Descriptors: *Irrigation, *Benefits, Value, Costs, Projections, Economics, Pumping.
Identifiers: *High Plains, *Secondary benefits, *Tertiary benefits, Farm income, Agriculture, Farmers.

The economy of the High Plains of West Texas is strongly dependent upon irrigated agriculture. Without the Texas Water Plan, or some similar plan for the importation of water to the High Plains, irrigated agriculture in the High Plains will shortly start a decline that will end in oblivion in less than a century. Of far greater significance will be the decline of secondary and tertiary benefits to other sectors of the economy. Secondary and tertiary benefits associated with irrigation had been estimated to range from about four times the primary benefits in a dry year to about seven times the primary benefits in a reasonably wet year. Current status of irrigation in High Plains, value of irrigation to the High Plains economy, and present cost of irrigation water in High Plains were discussed. It concluded that water should be imported to the High Plains to sustain and enhance the present level of irrigated agriculture in the area.

70-71:06D-002
LINEAR PROGRAMMING MODEL FOR ESTIMATING THE AGRICULTURAL DEMAND FUNCTION FOR IMPORTED WATER IN THE PECOS RIVER BASIN,
Gisser, Micha.
New Mexico University, Albuquerque, Dept of Economics.
Available from National Technical Information Service as PB-194 785, $3.00 in paper copy, $0.95 in microfiche. Project Completion Report, July 1970. 13 p, 1 fig, 1 tab.

Descriptors: *Water demand, *Systems analysis, *Economic prediction, *Planning, *Semiarid climates, Irrigation, Crops, Water allocation (Policy), Water costs, Water utilization, Water values, Semiarid climates, Model studies, Estimating equations, Linear programming, Constraints, Irrigation water, Agriculture.
Identifiers: *Pecos River Basin, Water importation.

A linear programming model of agricultural demand for imported water was developed for the Pecos Basin. The model utilizes agricultural activities and obtains agricultural demand functions for differing imported water prices and for local water use constraints. A constraint (L) indicates the highest per acre quantity of irrigation water farmers are allowed to use. The types of constraint incorporated into the model were salinity, legal, vegetables (greater than 20 percent production leads to oversupply), acreage and cotton (allotments). The basic assumptions of the model were: (1) Agricultural production can be divided into separate independent activities, (2) Each activity is governed by constant return to scale and fixed proportions, (3) Activities are divisible. The demand results are shown for L-3 at various local and imported water prices.

70-71:06D-003
DEMAND MANAGEMENT THROUGH RESPONSIVE PRICING,
Hanke, S. H., and Davis, R. K.

John Hopkins University, Baltimore, Maryland; and George Washington University,
Washington, D.C.
Journal of the American Water Works Associations, Vol. 63, No. 9, p 555-560,
September 1971. 1 fig, 5 tab, 18 ref.

Descriptors: *Water supply, *Economic efficiency, *Planning, *Pricing, *Water demand, Time, Average costs, Marginal costs, Investment.
Identifiers: *Economic equity, *Responsive pricing, *Washington, D.C.

A responsive pricing policy plus effective management of supply will assure more efficient use of the resources employed to produce and distribute water and more equitable distribution of water service costs. The technical solutions of conventional supply management disregard rising water supply costs and diminishing marginal values. A policy of demand management through responsive pricing will balance the marginal value against the marginal cost of water utility investments. In the temporal aspect of water supply and demand, a 'peak-load problem' exists where peak demands guide water utility investments unrestrained by prices which reflect the peak-load marginal cost. By sizably reducing long-run water supply requirements, the responsive pricing rule solves the peak-load problem more efficiently than uniform average cost pricing. These results are cited in a case study of the Washington, D.C. metropolitan area. The implications for this area, where the growth of summertime demand is leading to capacity expansion pressures, are that growth in storage facilities and system capacity can be postponed possibly beyond 10 years. This will result in a substantial reduction in the discounted costs of an investment.

SECTION XXXI

WATER RESOURCES PLANNING

WATER LAW AND INSTITUTIONS (Group 06E)

70-71:06E-001
TECHNICAL AND INSTITUTIONAL ASPECTS OF SEWAGE EFFLUENT-IRRIGATION WATER EXCHANGE, TUCSON REGION,
Cluff, C. B., DeCook, K. J., and Matlock, W. G.
Arizona University, Tucson.
Water Resources Bulletin, Vol. 7, No. 4, p 726-739, August 1971. 2 fig, 1 tab, 8 ref.

Descriptors: *Water transfer, *Sewage effluents, *Irrigation, *Water reuse, Economic efficiency, Legal aspects, Water quality, Agriculture.
Identifiers: *Arizona, *Technical and institutional aspects, Municipal use.

Many growing municipalities near irrigated agriculture are advocating a transfer of water now utilized for irrigation to municipal use. Alternatives are presented whereby this water can be transferred to municipal use in exchange for treated sewage effluent. The irrigation water would in effect be cycled through the municipal system prior to use on the farms. A case study of the Tucson region illustrates the relevant legal, economic and technical aspects. Effluent could be delivered to irrigators in Avra Valley at a cost less than that now paid for water pumped from declining water tables. In return the city of Tucson could import ground water now being used for irrigation through an existing pipeline which presently cannot be used because of a court injunction obtained by the irrigators. It appears that such an exchange agreement could be made without modification of existing statutory law. Similar exchange arrangements may prove to be feasible in other regions containing irrigated agriculture. Increased efficiency of water use can be achieved avoiding external effects which commonly arise in a direct transfer and are difficult to evaluate. High quality water is allocated to municipal use whereas nutrient-rich sewage effluent is transferred to irrigation.

70-71:06E-002
CAN ENGINEERING FORECASTERS EFFECT WATER LAW?,
Reid, G. W., Pritchett, E. E., and Pritchett, S.
Oklahoma University, Norman, Bureau of Water Resources Research.
American Society of Civil Engineers, Journal of the Sanitary Engineering Division, Vol. 97, No. SA4, Proc. Paper 8329, p 479-484, 1971. 1 tab.

Descriptors: *Forecasting, *Legislation, *Water law, *Water resources, Sanitary engineering, Water rights, Ecology.
Identifiers: Riparion, Res Communes, Appropriation, Gross National Product.

The writers have pointed out the emerging water resources problems associated with the escalation of the nation's life style and population growth made possible by unprecendented technological capability. The importance of shear magnitude and short response time as well as an evident shift of emphasis from an open loop to a closed loop system was also stressed. Engineering has accepted the necessity of advance planning and exploration of alternates using the systems approach looking at possible and probable worlds. Comprehensive systems with roots firmly grounded in the future are required to meet the needs before they present themselves, freeing the engineer from historic and rigid laws. The Riparian, and appropriation doctrines are all found wanting, and based on a Res Communes doctrine legislative law is suggested that will provide for operation and management of water resources system in an optimal fashion, permitting engineers, economists, and lawyers to work together placing technological and ecological priorities in their proper perspective. Such a system would protect long-term investment, enable long-range planning and establish alternative goals.

SECTION XXXII

RESOURCES DATA

DATA ACQUISITION (Group 07B)

70-71:07B-001
DEPTH TO GROUND-WATER TABLE BY REMOTE SENSING,
Abdel-Hady, M., and Karbs, H. H.
Oklahoma State University, Stillwater, Dept of Civil Engineering.
American Society of Civil Engineers Proceedings, Journal of the Irrigation and Drainage Division, Vol. 97, No. IR3, Paper 8360, p 355-367, September 1971.
7 fig, 1 tab, 10 ref.

Descriptors: *Soil moisture, *Water table, *Remote sensing, Infrared radiation, Solar radiation, Surveys, Mapping, Photogrammetry, Temperature.
Identifiers: *Infrared imaging.

Infrared imagery was tested as a technique for remote sensing and surveying depth to the groundwater table. The variation of soil radiant energy in the 8-14 micron infrared spectral band is affected by depth to groundwater table. Differences in depth to groundwater table, within the 0 ft to 4 ft level, in 2 types of soils tested, were detectable by ground surface radiance measurements. During the period of investigation (summer), radiant intensity was maximum from 2 p.m. - 4 p.m. Maximum radiant intensity differences resulting from variations to depth of water table also occurred during this period. The differences in radiance during the peak period were significant, suggesting excellent potential applications of most good imaging systems in detecting and surveying depth to groundwater table and soil moisture variations.

70-71:07B-002
SOIL MOISTURE DETECTION WITH IMAGING RADARS,
MacDonald, Harold C., and Waite, William P.
Kansas University, Lawrence, Remote Sensing Laboratory.
Water Resources Research, Vol. 7, No. 1, p 100-110, February 1971. 11 p,
7 fig, 22 ref.

Descriptors: *Soil moisture, *Remote sensing, *Radar, *Mapping, Surveys, Soil water, Soil classifications, Soil investigations, Soil physical properties, Soil types, Vegetation effects, Arctic, Permafrost.
Identifiers: *Radar (Imaging), *Radar (Side-looking).

The effects of soil moisture are extremely difficult to separate from other terrain parameters influencing the radar return signal. Presently available dual polarized, K-band, side-looking imaging radars provide a capability for revealing a qualitative estimate of soil moisture content. When used as a supplement to aerial photography in temperate climates, radar imagery analysis can provide data for mapping regions of permafrost, and this process could be accomplished regardless of weather or time of day.

70-71:07B-003
IMPROVEMENTS IN THE VAN BAVEL-MYERS AUTOMATIC WEIGHING LYSIMETER,
Rosenberg, Norman J., and Brown, K. W.
Nebraska University, Lincoln.
Water Resources Research, Vol. 6, No. 4, p 1227-1229, August 1970. 3 p, 1 fig,
9 ref.

Descriptors: *Lysimeters, *Automation, *Instrumentation, *Evapotranspiration, Design, Equipment, Nebraska.
Identifiers: Automatic weighing lysimeters.

The performance of the Van Bavel-Myers lysimeter was improved in two units installed at Mead, Nebraska. The units function according to design

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specifications (0.01 mm precision; 0.05 mm accuracy) after the following modifications were made: (1) provide drainage to maintain underground portions of the lysimeter in a water free condition, (2) relocate the electrical junctions to assure high electrical resistance between ground and the strain gage load cell, and (3) make mechanical damping devices accessible for cleaning and adjustment.

70-71:07B-004
A NEW CONDUCTIVITY METHOD FOR DETERMINING CONCENTRATIONS IN PARALLEL PLATE MODELS,
Bachmat, Y., and Lawson, D. W.
Guelph University, (Ontario).
Journal of Hydrology, Vol. 11, No. 2, p 145-158, August 1970. 14 p, 9 fig, 2 tab, 5 ref.

Descriptors: *Hydraulic models, *Groundwater movement, *Instrumentation, *Electrical conductance, Water levels, Solutes, Tracers, Ion transport, Salinity, Flow, Percolation, Velocity, Mixing.
Identifiers: Parallel-plate models.

A new electrical-conductivity method was developed to determine solute concentrations in parallel plate sand models of flow in porous media. The method consists of using two circular electrodes mounted flush in the opposing walls of the model and facing each other on a common normal to the walls. Such an arrangement provides measurements which are averaged across the thickness of the medium and does not modify the local flow pattern or cause local variations in the packing of the porous medium. A method is developed which can be used to determine the volume of the porous medium that is being sampled. The measurements are stable and reproducible for platinum and platinized titanium electrodes and a glass bead medium at concentrations greater than 0.01 N $CaCl_2$. Each electrode pair must be calibrated in the model in the presence of the porous medium.

70-71:07B-005
EVALUATION OF SELECTED COBALT-60 COMPLEXES AS TRACERS OF GROUNDWATER,
Bruscato, Frank N., and McHenry, J. Roger.
Northeast Louisiana State College, Monroe, Dept of Chemistry; and Agricultural Research Service, Oxford, Mississippi.
Journal of Hydrology, Vol. 10, No. 4, p 406-417, June 1970. 12 p, 3 fig, 6 tab, 16 ref.

Descriptors: *Tracers, *Cobalt radioisotopes, *Groundwater movement, Ion exchange, Clay minerals, Laboratory tests, Radioisotopes, Radioactivity techniques, Translocation.
Identifiers: Complexes.

A series of Co-60 compounds, considered as potentially useful tracers of groundwater movement, were prepared and evaluated in soil column and batch studies. The compounds were: potassium hexacyanocobaltate (III), potassium ethylenediamminetetraacetato-cobaltate (III), ammonium 12-tungstodi-cobaltoate (III), chloraquotetrammine cobalt (III) chloride, and sodium hexanitrocobaltate (III). The performance of the complexes of CN and EDTA were dependent on their environment and more especially on the type and amount of clay present. The EDTA cobalt complex cannot be used in soils that bare basic or where a large fraction of the clay is saturated with Na or Ca. Of the other radioactive tracers tested, none were suited for groundwater tracing because of instability in aqueous solution, variable anionic structure under acid conditions, or preferential uptake by the clay fraction.

70-71:07B-006
AIR PERMEABILITY AS RELATED TO PARTICLE SIZE AND BULK DENSITY IN SAND SYSTEM,
Elgabaly, M. M., and Elghamry, W. M.
Alexandria University, United Arab Republic.
Soil Science, Vol. 110, No. 1, p 10-13, July 1970. 1 fig, 2 tab, 16 ref.

Descriptors: *Porous media, *Permeability, Porosity, Particle size, Bulk density, Mathematical models, Permeameters.
Identifiers: *Air permeability, Sand systems, Pore size.

A system was devised to measure the air permeability of several samples of sand. From these data, two mathematical models were developed to predict the air permeability of samples based on the particle size distribution. Equations were then written and their solutions obtained.

70-71:07B-007
MEASUREMENT OF UNSATURATED CONDUCTIVITY AND DIFFUSIVITY BY INFILTRATION THROUGH AN IMPEDING LAYER,
Hillel, D., and Gardner, W. R.
Wisconsin University, Madison.
Soil Science, Vol. 109, No. 3, p 149-153, March 1970. 2 fig, 10 ref.

Descriptors: *Soil science, *Soil moisture, *Unsaturated flow, Conductivity, Diffusivity, Infiltration.
Identifiers: *Impeding layer, Soil crust, Field method.

A method is described for measuring the hydraulic transmission properties of a soil column as a function of water content. It involves a series of infiltration trials through capping plated (or crusts) of different hydraulic resistance to induce the development of a suction at the surface. An actual measurement of the capillary conductivity is obtained by allowing the process to proceed to the steady stage, and the use of progressively impeding plates give progressively smaller conductivity values corresponding to lower water contents.

70-71:07B-008
VISIBLE AND NEAR INFRARED REMOTE-SENSING OF SOIL MOISTURE LEVELS,
Sewell, J. I., Allen, W. H., and Pile, R. S.
Tennessee University, Knoxville.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 6, p 1163-1166, June 1971. 5 fig, 4 tab, 9 ref.
(See 70-71:02G-080)

SECTION XXXIII

ENGINEERING WORKS

STRUCTURES (Group 08A)

70-71:08A-001
INTERCEPTOR DRAIN RECOVERY OF CANAL SEEPAGE,
Willardson, L. S., Boles, A. J., and Bouwer, H.
Agricultural Research Service, Brawley, California; and Imperial Irrigation District, California; and Agricultural Research Service, Phoenix, Arizona, Water Conservation Laboratory.
Transactions, American Society of Agricultural Engineers, Vol. 14, No. 4, p 738-741, July-August 1971. 2 fig, 5 tab, 6 ref.

Descriptors: *Subsurface drains, *Canal seepage, *Analog models, Drains, Subsurface drainage, Water loss, On-site investigations, Laboratory tests, Base flow, Flow measurement, Groundwater, Canal design, Canals.
Identifiers: *Water recovery, Imperial Irrigation Distirct (California), Open drains, Seepage losses, Drain spacing.

Canal seepage is a problem throughout the world. Because canal lining is not economically feasible for all canals, alternatives must be sought to avoid some seepage problems. One alternative is the installation of interceptor drains near the canal to recover and pump seepage water back into the canal. Water recovery would alleviate water loss and high water tables. Field and laboratory investigations were conducted on the East Highline Canal, Imperial Irrigation District, California, to develop design criteria for interceptor drains adjacent to canals. A 14-in.-dia concrete pilot seepage interceptor drain, 2550 ft long, was installed 9 ft deep and 104 ft from the canal centerline. The drain discharge is approximately 3 cfs but varies with the canal water level. Readings of drain discharge vs. canal water surface elevation, water table levels, and piezometer water levels, were taken over a period of time. These data were used to model the ground-water system on an electric analog. Data from the analog indicate that drains should be as deep and as far from the canal as practicable. Reducing drain inflow resistance improves the efficiency of water recovery, indicating the need for well-designed drain envelopes.

70-71:08A-002
AUTOMATION OF SURFACE IRRIGATION WITH FLUIDIC DIVERTERS,
Kruse, E. G., Freeman, P. A., and Haise, H. R.
United States Department of Agriculture, Fort Collins, Colorado, Agricultural Research Service.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 3, p 357-361, March 1970. 11 fig, 6 ref.

Descriptors: *Irrigation practices, *Surface irrigation, *Automation, Irrigation structures.
Identifiers: *Flow dividers, Fluidic dividers.

Fluidic diverters can be designed to divert a stream of water from one to the other of two outlets, using no moving parts and no external source of energy. Diverters can be sized to carry discharges from a fraction of a gallon per minute up to several cubic feet per second. Irrigation diverters with approximate capacities of 2 and 5 cfs were operated in laboratory flumes. Operating heads, head losses, and discharges through the range of effective diverter performance were recorded. Control systems suitable for use in automating surface irrigation systems were developed. The diverters were further tested in the field with very satisfactory results.

70-71:08A-003
EFFECT OF VEGETAL LENGTH AND SPATIALLY VARIED FLOW ON VELOCITY DISTRIBUTION COEFFICIENTS,
McCool, D. K.
United States Department of Agriculture, Stillwater, Oklahoma.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 5, p 603-607, May 1970. 9 fig, 4 tab, 14 ref.

Descriptors: *Open channel flow, *Grassed water ways, Canal design, Roughness (hydraulic).
Identifiers: Spatially varied flow.

Experiments were conducted to test the soundness and applicability to the runoff generation process of the spatially varied flow on the Coriolis or velocity head coefficient and on the Boussinesq or momentum coefficient in equation for open channel flow are illustrated. This information reduces the undefined variables in testing the hypothesis of the spatially-varied flow equations and aids in the design of grass channels. Conclusions drawn were: 1. Coriolis and Boussinesq coefficients are a linear function of grass length to hydraulic radius. 2. Spatially varied flow had no effect on the Coriolis and Boussinesq coefficients. 3. Coriolis and Boussinesq coefficients were much larger than expected. 4. Coriolis coefficient has a significant effect on energy slope and hence on Manning's coefficient where curvilinear flow in a small grassed channel is involved.

SECTION XXXIV

ENGINEERING WORKS

HYDRAULICS (Group 08B)

70-71:08B-001
THE APPROPRIATE GRADE OF A GATED PIPE,
Chu, S. T., and Moe, D. L.
South Dakota State University, Brookings.
American Society of Agricultural Engineers, Transactions, Vol. 14, No. 4,
p 727-733, April 1971. 1 fig, 2 tab, 5 ref.
(See 70-71:04A-044)

SECTION XXXV

ENGINEERING WORKS

HYDRAULIC MACHINERY (Group 08C)

70-71:08C-001
CENTER PIVOT IRRIGATION,
Heermann, D.
Colorado State University, Fort Collins, Department of Agricultural Engineering.
World Irrigation, Vol. 20, No. 4, p 8-11, June 1970. 6 fig, 1 tab.
(See 70-71:04A-017)

70-71:08C-002
AN AUTOMATED SURFACE IRRIGATION VALVE,
Fischbach, P. E., and Goodding, R., II.
Nebraska University, Lincoln, Dept of Agricultural Engineering; and Murphy (Frank W.) Manufacturers, Tulsa, Oklahoma.
Agricultural Engineering, Vol. 51, No. 11, p 584-585, November 1971. 5 fig.

Descriptors: *Irrigation systems, *Irrigation engineering, *Automatic control.
Identifiers: *Surface irrigation valves.

If any part of an individual surface irrigation system fails, it appears best that all valves automatically open to let the water flow down all furrows of the fields involved until repairs can be made. Electric controls for automated surface irrigation systems with a reuse system have been developed. In the irrigation controller a time clock, relays, time-delay relays and stepping relays control small 3-way solenoid valves that control the air to the automatic valves. The automated valve connects to a riser on a buried pipeline or a tee in a supply line. Gated pipe is connected to the valve to distribute water down the furrows. The dimensions and placement of the valve assembly are described and diagrammed. Field tests in which 15 valves were satisfactorily used are described.

SECTION XXXVI

ENGINEERING WORKS

SOIL MECHANICS (Group 08D)

70-71:08D-001
NON-LINEAR THERMODYNAMICS OF SOIL-WATER-HEAT SYSTEMS,
Pal R., and Gupta, M. P.
Haryana Agricultural University, Hissar (Haryana) India.
Journal of Hydrology, Vol. 11, No. 3, p 313-315, March 1970. 8 ref.
(See 70-71:02F-037)

70-71:08D-002
RELATION BETWEEN ENERGY AND ERROR DUE TO NUCLEAR STATISTICS FOR DENSITY MEASUREMENT BY GAMMA RAY TRANSMISSION,
Preiss, K.
Negev Institute for Arid Zone Research, Beer-Sheva, Israel.
Soil Science, Vol. 110, No. 3, p 151-156, September 1970. 2 fig, 8 ref.

Descriptors: *Gamma ray, *Soil density probes, *Density, Radiation, Nuclear meters, Mass.
Identifiers: Density measurement.

When measuring density by gamma ray transmission through a thickness of material, the time of counting for a given standard error of density due to nuclear statistics depends on the energy of the radiation. This paper analyzes the relationship between this time interval and the radiation energy.

70-71:08D-003
THERMODYNAMICS OF SOIL-WATER SYSTEM,
Pal, R., and Gupta, M. P.
Haryana Agricultural University, Hissar, Haryana, India.
Journal of Hydrology, Vol. 13, No. 3, p 278-280, September 1971. 8 ref.
(See 70-71:02F-044)

70-71:08D-004
HYDROSTATICS IN SWELLING SOILS AND SOIL SUSPENSIONS: UNIFICATION OF CONCEPTS
Philip, J. R.
Commonwealth Scientific and Industrial Research Organization, Canberra City, Australia, Division of Plant Industry.
Soil Science, Vol. 109, No. 5, p 294-298, May 1970. 6 ref.

Descriptors: *Soil mechanics, *Soil physical properties, Hydrostatic pressure, Overburden.
Identifiers: *Swelling, *Soil suspensions, Brownian motion, Double layer, Moisture potential, Gravitational potential, Overburden potential.

The paper examines the question whether the concepts for water soil relationships hold true to dilute soil suspension subject to gravity and Brownian motion (double layer effects being negligible). It is shown that they do and that in such systems, the moisture potential is minus the "colloid osmotic pressure." Moisture potential is a unique function of the moisture ratio for (i) any suspension under equilibrium conditions and (ii) a suspension of uniform particles under either non-equilibrium or equilibrium conditions.

70-71:08D-005
RELATION OF MOISTURE CONTENT TO FAILURE STRENGTHS OF SEVEN AGRICULTURAL SOILS,
Chancellor, W. J., and Vomocil, J. A.

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California University, Davis.
American Society of Agricultural Engineers, Transactions, Vol. 13, No. 1, p 9-17, January 1970. 9 fig, 2 tab, 8 ref.

Descriptors: *Soil physics, *Soil strength, *Soil moisture, Soil mechanics, Soil stability, Moisture content.
Identifiers: Agricultural soil.

Failure strengths of agricultural soils at moisture content normal for crop production tend to increase as moisture content decreases. This paper presents a hypothesis for relating these two characteristics. The hypothesis is one which would allow the prediction of the internal intergranular bonding stress for any moisture content in excess of 15 bars soil moisture suction, provided the moisture content-soil moisture suction relationship is known. The hypothesis is based on a mechanistic model of how moisture is held in the soil, and how it bonds soil particles together.

SECTION XXXVII

ENGINEERING WORKS

FISHERIES ENGINEERING (Group 08I)

70-71:08I-001
FERTILIZERS,
Viets, F. G., Jr.
United States Department of Agriculture, Fort Collins, Colorado, Agricultural Research Service, Northern Plains Branch, Soil and Water Conservation Research Division.
Journal of Soil and Water Conservation, Vol. 26, No. 2, p 51-53, March-April 1971. 1 tab, 18 ref.
(See 70-71:05B-032)

SECTION XXXVIII

AUTHOR INDEX

Abdel-Hady, M.
70-71:07B-001

Abou-Khaled, Antoine
70-71:02D-004

Adams, J. E.
70-71:02I-003

Adrian, D. D.
70-71:02G-068

Aldabagh, A. S. Y.
70-71:02F-058

Alessi, J.
70-71:03F-037

Alexander, M. W.
70-71:03F-025

Alfaro, J. F.
70-71:02G-069

Alizai, H. U.
70-71:02D-021

Allen, L. H.
70-71:02D-001

Allen, P. B.
70-71:04D-001

Allen, S. E.
70-71:02K-016

Allen, W. H.
70-71:02G-080
70-71:03F-016
70-7 3F-017

Amir, J.
70-71:02K-017

Anderson, O. E.
70-71:02K-009
70-71:02K-014

Anderson, W. D.
70-71:02K-005

Apgar, M. A.
70-71:05B-004

Aron, Gert
70-71:02F-002

Ashburn, C. L.
70-71:03F-036

Aston, A. R.
70-71:02G-019

Attoe, O. J.
70-71:05E-001

Axthelm, L. S.
70-71:03F-036

Bachmat, Y.
70-71:02F-016
70-71:07B-004

Back, W.
70-71:02K-001

Baier, D. C.
70-71:05D-003

Baier, W.
70-71:03F-012

Bailey, J. W.
70-71:05G-001

Baird, Ralph W.
70-71:02E-009
70-71:05B-017

Bakker, J. W.
70-71:02G-053

Baldwin, R. E.
70-71:05F-002

Banker, R. F.
70-71:06C-002

Banner, James
70-71:02F-015

Barfield, B. J.
70-71:02I-021

Barnes, G. D.
70-71:05A-007

Barton, James R.
70-71:05B-047

Bassett, D. M.
70-71:02K-005

Bauer, William J.
70-71:05D-004

Beasley, R. P.
70-71:05B-049

Beer, C. E.
70-71:02A-001
70-71:02F-058

Ben-Asher, I.
70-71:03C-003

Bennett, O. L.
70-71:03F-020

Benson, R. B.
70-71:06C-002

Benyamini, Y.
70-71:02G-031
70-71:02G-032

Berg, C. C.
70-71:03F-032

Bernard, Harold
70-71:05A-001

Bhuiyan, S. I.
70-71:02G-019

Bianchi, W. C.
70-71:02F-042

Bibby, R.
70-71:02F-028

Biggar, J. W.
70-71:02G-022

Bird, N. A.
70-71:02G-074

Bishop, A. A.
70-71:03F-034
70-71:04A-037

Black, J. D. F.
70-71:02F-040

Black, R. D.
70-71:02E-012

Black, Richard D.
70-71:02G-027

Black, T. A.
70-71:02D-014
70-71:02F-030

Blackmore, A. V.
70-71:02F-025

Blevins, R. L.
70-71:02G-003

Blum, A.
70-71:03F-002

Boawn, L. C.
70-71:03F-026

Boersma, L.
70-71:02F-055

Preceding page blank

Bolander, W. J.
    70-71:05B-026

Boles, A. J.
    70-71:08A-001

Bolter, Ernst
    70-71:05A-010

Bond, J. J.
    70-71:03F-022
    70-71:03F-031

Bondurant, J. A.
    70-71:03F-065
    70-71:05B-019
    70-71:05B-040

Boswell, F. C.
    70-71:02K-008
    70-71:02K-009
    70-71:02K-014

Bouldin, D. R.
    70-71:05B-021

Boulogne, A. R.
    70-71:02G-033

Boulton, Norman S.
    70-71:02F-027
    70-71:04B-002

Bouwer, Herman
    70-71:02G-037
    70-71:05D-005
    70-71:08A-001

Boyd, L. L.
    70-71:02I-011

Boyer, J. S.
    70-71:03F-023

Bradley, E.
    70-71:02F-036

Branson, F. A.
    70-71:02J-002

Bridie, A. L. A. M.
    70-71:05B-018

Broadbent, F. E.
    70-71:02G-052

Brooks, R. H.
    70-71:02G-048

Brown, K. W.
    70-71:07B-003

Brown, P. L.
    70-71:02D-018

Brown, Randall L.
    70-71:05D-010
    70-71:05D-011

Bruch, John C., Jr.
    70-71:02F-017

Bruscato, Frank N.
    70-71:07B-005

Brustkern, Richard L.
    70-71:02G-013

Brutsaert, Wilfried
    70-71:02G-026

Brutsaert, W. F.
    70-71:02G-018

Bruvold, W. H.
    70-71:05F-004

Bucks, D. A.
    70-71:02F-052

Burchinal, Jerry C.
    70-71:05A-002

Bureau of Reclamation
    70-71:03F-045

Burman, R. D.
    70-71:02E-012

Cady, Foster B.
    70-71:05B-017

Callinan, B. J.
    70-71:03C-017

Campbell, L. C.
    70-71:02K-043

Cardon, Doyle R.
    70-71:05D-012

Carreker, John R.
    70-71:02D-002

Carson, C. D.
    70-71:02K-028

Carter, D. L.
    70-71:05B-019

Cary, J. W.
    70-71:03F-015

Cassai, N.
    70-71:03F-047

Caswell, C. A.
    70-71:05B-058

Chancellor, W. J.
    70-71:08D-005

Chen, L. H.
    70-71:02I-013

Chernyak, G. Y.
    70-71:06A-006

Chidley, Thomas R. E.
    70-71:02D-006

Childs, E. C.
    70-71:02F-004

Chow, Ven Te
    70-71:04A-013

Chu, S. T.
    70-71:04A-044

Claassen, M. M.
    70-71:02I-004
    70-71:02I-005

Clark, R. N.
    70-71:02G-082
    70-71:03F-013

Clark, S. D.
    70-71:03C-018

Cluff, C. B.
    70-71:06E-001

Cochran, V. L.
    70-71:03F-006

Coe, Jack J.
    70-71:05C-005

Coleman, C.
    70-71:03F-054

Colorado River Board
  of California
    70-71:05G-020

Colwick, R. F.
    70-71:02G-076

Conner, J. R.
    70-71:06B-001

Constantin, G. K.
    70-71:02K-027

Cook, Doyle
    70-71:02G-003

Cooper, L. R.
    70-71:02K-003

Corey, A. T.
    70-71:02G-048
    70-71:02G-049

Corey, G. L.
    70-71:02G-048

Corey, J. C.
    70-71:02G-033

Corrigan, P. A.
    70-71:05A-007

Cossens, G. G.
70-71:02F-033
70-71:02G-050

Cowlishaw, Wayne
70-71:05D-004

Crites, R. W.
70-71:05D-001

Crosby, James W., III
70-71:05B-010

Cullen, E. M.
70-71:03C-001

Curry, R. B.
70-71:02I-013
70-71:02I-022

Cypra, Kenneth J.
70-71:05D-004

Dabiri, Hassan
70-71:02F-026

Dagan, Gedeon
70-71:02F-012

Daigger, L. A.
70-71:03F-036

Dasberg, S.
70-71:02G-053

Davenport, David C.
70-71:02D-004

David, W. P.
70-71:03F-038

Davis, R. G.
70-71:03F-004

Davis, R. K.
70-71:06D-003

Davis, Sterling
70-71:03F-011

Day, A. D.
70-71:03F-001
70-71:03F-033

Decker, W. L.
70-71:02D-012

DeCook, K. J.
70-71:06E-001

DeLong, Lewis
70-71:05A-005

Delwiche, C. C.
70-71:02G-083

Denholm, W. T.
70-71:05G-022

Denmead, O. T.
70-71:02D-019

DeRemer, E. D.
70-71:03C-009
70-71:03C-012

Dickey, G. L.
70-71:05G-001

Doss, B. D.
70-71:03F-027
70-71:03F-057

Downey, Lloyd A.
70-71:03F-003

Drake, Ronald L.
70-71:02F-005
70-71:02G-089

Drew, J. V.
70-71:05C-007

Dudley, N. J.
70-71:06A-002
70-71:06A-003

Duke, H. R.
70-71:02G-049

Duncan, W. G.
70-71:02I-021

Dunne, Thomas
70-71:02G-027

Dusek, D. A.
70-71:03F-068

Dylla, Anthony S.
70-71:02D-007
70-71:02F-054
70-71:02G-006
70-71:04A-001

Eagleman, J. R.
70-71:02D-010

Eck, H. V.
70-71:03F-004

Edwards, D. M.
70-71:04A-019

Edwards, W. M.
70-71:05B-011

Eichelberger, James W.
70-71:05B-061

Elgabaly, M. M.
70-71:07B-006

Elghamry, W. M.
70-71:07B-006

Ellingson, Michael B.
70-71:02G-089

Ellis, J. H.
70-71:01B-001

Ellis, W. R.
70-71:02F-019

Elrick, D. E.
70-71:02F-016

Enfield, C. G.
70-71:02G-020

England, H. N.
70-71:02K-044

Environmental Science and Technology
70-71:05B-055
70-71:05B-057

Ephrat, J.
70-71:02K-017

Epstein, E.
70-71:02J-001

Ernst, L. F.
70-71:02F-021

Evans, J. O.
70-71:05D-016

Fairbourn, M. L.
70-71:02D-013

Farr, E.
70-71:02G-061
70-71:02K-020

Faulkner, L. R.
70-71:05B-026

Fenton, Robert L.
70-71:05B-010

Fischbach, P. E.
70-71:04A-038
70-71:04A-045
70-71:08C-002

Fok, Yu-Si
70-71:02F-051
70-71:02G-057
70-71:02G-058
70-71:04A-037

France, P. W.
70-71:02F-029

Franzoy, Carl Eugene
70-71:02G-090
70-71:03F-010
70-71:03F-029

Freeman, P. A.
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Freeze, R. Allan
    70-71:02F-010
    70-71:02F-015

Frere, M. H.
    70-71:05B-025

Freund, R. J.
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Frink, C. R.
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Fryrear, D. W.
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    70-71:04A-025

Fuhriman, Dean K.
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Fulgham, F. E.
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Furusaka, C.
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Gage, P. W.
    70-71:02K-041

Garber, M. J.
    70-71:03C-001

Gardner, H. R.
    70-71:02D-001
    70-71:02D-013

Gardner, W. R.
    70-71:02D-014
    70-71:02F-030
    70-71:02G-031
    70-71:02G-032
    70-71:02G-062
    70-71:02I-006
    70-71:07B-007

Garner, B. J.
    70-71:03F-042

Garton, J. E.
    70-71:04A-039

Gat, J. R.
    70-71:02F-006

Geist, J. M.
    70-71:02K 006
    70-71:02K-007

Ghorashy, S. R.
    70-71:03F-023

Gilchrist, A. N.
    70-71:05B-020

Gillingham, A. G.
    70-71:05B-020

Giordana, P. M.
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Gisser, Micha
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    70-71:06D-002

Glandon, Lawrence R.
    70-71:05B-022

Glass, L. J.
    70-71:03F-013

Godwin, M. R.
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Goldberg, Marvin C.
    70-71:05A-005

Goldberg, D.
    70-71:03C-002
    70-71:03C-003

Goltz, S. M.
    70-71:02D-008

Goodding, R., II.
    70-71:08C-002

Gornat, B.
    70-71:03C-003

Gradner, W. R.
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Graham, E. R.
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Grant, W. J.
    70-71:02J-001

Grass, L. B.
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Gratto, C. P.
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Grauze, G.
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Gray, A. S.
    70-71:04A-021

Gray, Don M.
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    70-71:02G-079

Green, Don W.
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Gregory, E. J.
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Greweling, T. E.
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Grimme, H.
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Grinstead, Robert R.
    70-71:05D-009

Grissinger, E. H.
    70-71:05B-003

Groenewoud, W. M.
    70-71:05B-018

Guitjens, J. C.
    70-71:02F-011
    70-71:02F-054

Gulati, Om P.
    70-71:04D-002

Gupta, M. P.
    70-71:02F-037
    70-71:02F-044

Gupta, U. C.
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Guymon, G. L.
    70-71:05B-013

Haan, C. T.
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Hagan, Robert M.
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    70-71:02G-001
    70-71:02G-017

Haise, H. R.
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Hall, F. G.
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Hall, Francis R.
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Hanke, S. H.
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Hanks, R. J.
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Hanshaw, B. B.
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Harlin, Curtis C.,
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Harmeson, Robert H.
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Harris, W. S.
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Hassan, N. A. K.
    70-71:05C-007

Hatcher, J. T.
    70-71:02K-026

Heermann, D. F.
    70-71:03F-007
    70-71:04A-017
    70-71:04A-030

Henderson, D. W.
    70-71:03F-024

Hendrick, J. G.
    70-71:02G-034

Hensler, R. R.
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Hermanson, R. E.
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Herrmann, L. R.
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Hiler, E. A.
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    70-71:02G-082
    70-71 03F-013
    70-71:03F-038
    70-71:04A-031

Hill, D. E.
    70-71:02K-036

Hillel, D.
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    70-71:02G-032
    70-71:02G-062
    70-71:07E-007

Hipp, B. W.
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Hittle, C. N.
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Hodge, Carl O.
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Hoffman, G. J.
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Holmes, J. W.
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Holt, R. F.
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    70-71:05B-024

Horn, M. E.
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Hornberger, George M.
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    70-71:02G-029

Horner, G. M.
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Horowitz, A.
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Horton, J. H.
    70-71:02G-033

Howe, O. W.
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Howell, D. T.
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    70-71:06A-003

Howell, T. A.
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Howells, David H.
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Hsieh, J. J. C.
    70-71:02G-020

Huddleston, Ellis W.
    70-71:05B-002

Huggins, L. F.
    70-71:02G-007

Hulbert, L. C.
    70-71:02D-021

Hull, J. L.
    70-71:03F-024

Humpherys, A. S.
    70-71:04A-026

Hunt, C. M.
    70-71:02K-016

Hyle, R. C.
    70-71:06C-003

Intalap, Suhbawatr
    70-71:03F-001

Irrigation Age
    70-71:03F-069

Irrigation Journal
    70-71:03C-011
    70-71:03F-043
    70-71:03F-044
    70-71:04A-018
    70-71:04B-006

Jackson, Donald R.
    70-71:02F-002

Jackson, G. D.
    70-71:02D-011

Jacobson, R. L.
    70-71:02F-039
    70-71:05A-006

Jamieson, D. G.
    70-71:04C-003

Jaske, R. T.
    70-71:05B-012

Jensen, Albert C.
    70-71:05C-016

Jensen, M. E.
    70-71:02G-043
    70-71:03F-010

John, M. K.
    70-71:02I-018

Johnson, D. D.
    70-71:02K-007

Johnson, H. P.
    70-71:02A-001

Johnston, T. H.
    70-71:02K-023

Johnston, William R.
    70-71:05F-001

Johnstone, Donald L.
    70-71:05B-010

Jones, Elmer E., Jr.
    70-71:05B-006

Jones, J. W.
    70-71:02G-076
    70-71:02G-081

Jones, James R.
    70-71:05D-006

Jones, Kenneth C.
    70-71:05D-009

Jones, L. S.
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Jordan, K, A.
    70-71:02I-011

Jung, G. A.
    70-71:03F-020

Kahn, Lloyd
    70-71:05A-005

Karbs, H. H.
    70-71:07B-001

Kaspar, I.
70-71:02G-015

Kassander, A. Richard, Jr.
70-71:02D-020

Kastanek, F.
70-71:02G-035

Keller, Jack
70-71:02G-005
70-71:02G-069
70-71:02G-075

Kemper, W. D.
70-71:02D-013

Keup, Lowell E.
70-71:05B-016

Kevi, L.
70-71:02F-019

Khan, Muhammed Yunus
70-71:02F-013

Kincaid, D. C.
70-71:04A-030

King, D. C.
70-71:03F-027

Kirkham, Don
70-71:02F-013
70-71:02G-009
70-71:02G-010

Kirkpatrick, R. M.
70-71:03F-033

Klausner, S. D.
70-71:05B-021

Kleinecke, David
70-71:02F-020

Knisel, Walter G.
70-71:05B-017

Knudsen, D.
70-71:05C-007

Koon, J. L.
70-71:02G-034

Koronkevich, N. I.
70-71:04C-002

Koshi, P. T.
70-71:03F-005
70-71:04A-025

Kritz, George J.
70-71:03F-008

Kriz, G. J.
70-71:02F-053

Krous, E. S.
70-71:03C-004

Kruse, E. G.
70-71:04A-012
70-71:08A-002

Kumagai, James S.
70-71:05C-002

Kunze, G. W.
70-71:02K-028

Kuraz, V.
70-71:02G-015

Kutilek, M.
70-71:02G-015

Laflen, J. M.
70-71:02E-001

Lagerwerff, J. V.
70-71:02I-017

Lal, R.
70-71:04A-011

Lambert, J. R.
70-71:02G-084
70-71:03F-016
70-71:03F-017

Lancaster, J. D.
70-71:02K-015

Lane, Burke E.
70-71:02G-041

Lane, J. E.
70-71:01B-003

Lang, A. R. G.
70-71:02D-008
70-71:02I-006

Langdale, G. W.
70-71:02G-004

Langmuir, Donald
70-71:02F-039
70-71:05A-006
70-71:05B-004

Larson, T. E.
70-71:05A-003

Lathwell, D. J.
70-71:05B-021

Latterell, J. J.
70-71:05B-014

Law, James P., Jr.
70-71:05A-001
70-71:05B-048
70-71:05D-002
70-71:05G-014
70-71:05G-015

Lawson, D. W.
70-71:07B-004

Lembke, W. D.
70-71:02F-052

Lentz, G. L.
70-71:05B-049

Letey, J.
70-71:02K-010
70-71:02K-011
70-71:02K-012
70-71:02K-022

Levinson, A. A.
70-71:05A-004

Lewallen, M. J.
70-71:05B-005

Liang, Tung
70-71:03F-067
70-71:04A-008
70-71:04A-042

Lichtenberg, James J.
70-71:05B-061

Lidster, W. A.
70-71:04A-005

Lin, W.
70-71:02G-021

Linacre, E. T.
70-71:02D-015

Linderman, C. L.
70-71:04A-035

Lindstrom, F. T.
70-71:02F-055

Link, D. A.
70-71:04A-042

Livens, J.
70-71:02G-071

Locke, J. K.
70-71:02I-016

Longenecker, D. E.
70-71:02I-008

Lopez, P. L.
70-71:02K-025

Lundberg, P. E.
70-71:03F-020

Luthin, James N.
70-71:02F-011
70-71:02G-011

Luxmoore, R. J.
70-71:02K-010
70-71:02K-011
70-71:02K-012
70-71:02K-022

Lyerly, P. J.
70-71:02I-008

Lyons, C. G., Jr.
70-71:03C-010

Lyons, V. E.
70-71:05A-007

MacDonald, Harold C.
70-71:07B-002

Macfarlane, W. V.
70-71:02K-040

Makagonova, S. K.
70-71:06A-006

Mann, Patrick C.
70-71:06C-001

Mann, T. E.
70-71:04A-010

Mansfield, W. W.
70-71:01B-003

Martens, D. C.
70-71:03F-025

Martin, A. E.
70-71:02K-045

Martini, J. A.
70-71:02G-072

Martsolf, J. D.
70-71:02D-012

Massee, T. W.
70-71:03F-028

Mathias, E. L.
70-71:03F-020

Matlock, W. G.
70-71:02F-001
70-71:06E-001

Mayber, A. P.
70-71:02I-019

McCabe, L. J.
70-71:05C-003
70-71:05F-003

McCarty, P. L.
70-71:05C-004

McCool, D. K.
70-71:08A-003

McCorquodale, J. A.
70-71:02G-074

McDowell, L. L.
70-71:05B-003

McGuinness, J. L.
70-71:04C-001

McHenry, J. Roger
70-71:07B-005

McIlroy, I. C.
70-71:02D-019

McKeag, John A.
70-71:05F-001

McKee, Gerald D.
70-71:05B-016

McNeal, B. L.
70-71:02K-026

Meacham, I.
70-71:03C-018

Meek, B. D.
70-71:05G-001

Meiri, A.
70-71:02I-019

Melvin, S. W.
70-71:02A-001

Mengel, K.
70-71:02K-029

Merva, G. E.
70-71:02E-014

Metcalf, R. L.
70-71:05B-030

Metson, A. J.
70-71:02K-019

Meyer, Frederick W.
70-71:03C-006

Meyers, R. P.
70-71:02I-014

Michener, D. W.
70-71:02G-006

Middlebrooks, E. Joe
70-71:05C-002

Millar, A. A.
70-71:02D-008

Miller, S. A.
70-71:03F-021

Minshall, N. E.
70-71:05B-023

Mittra, B. N.
70-71:02I-007

Moe, D. L.
70-71:04A-044

Mojtehedi, M.
70-71:02G-054

Molz, F. J.
70-71:02G-002
70-71:02I-002

Monke, E. J.
70-71:02G-007

Moon, W. T.
70-71:02J-003

Morel-Seytoux, Hubert J.
70-71:02G-013

Morin, Joseph
70-71:02G-025

Mortvedt, J. J.
70-71:02G-047

Mueller, John A.
70-71:02K-002

Murphy, B. C.
70-71:02K-015

Musgrave, W. F.
70-71:06A-002
70-71:06A-003

Musick, J. T.
70-71:03F-068

Muspratt, M. A.
70-71:03F-014

Myers, R. G.
70-71:04A-019

Naghshineh-Pour, B.
70-71:02K-028

Nakamura, R.
70-71:02E-003

Nance, L. A., Jr.
70-71:02G-084

Nelson, Sheldon D.
70-71:03F-011

Nemeth, K.
70-71:02K-029

Neuman, Shlomo P.
70-71:02G-030

Ng, Benedict
70-71:02G-048

Nichols, M. S.
70-71:05B-023

Nicolaescu, I.
70-71:04A-012

Nielsen, D. R.
70-71:02G-017
70-71:02G-022

Nightingale, Harry I.
70-71:02F-042
70-71:05B-007

Nishio, M.
70-71:02K-018

Norum, Donald I.
70-71:02G-012
70-71:02G-079

Nott, J. H.
70-71:02K-019

Nye, P. H.
70-71:02G-061
70-71:02K-020

O'Connor, Donald J.
70-71:02K-002

Olson, R. A.
70-71:05C-007

Olson, R. J.
70-71:05E-001

Olson, Tamlin C.
70-71:02I-001

Onstad, C. A.
70-71:04C-003

Ortiz, Jaime
70-71:02G-011

O'Shaughnessy, F.
70-71:06A-001

Oster, C. A.
70-71:05B-012

Oster, J. D.
70-71:02G-042
70-71:02K-026

Owen, J. B.
70-71:02J-002

Painter, H. A.
70-71:05C-006

Pal, R.
70-71:02F-037
70-71:02F-044

Paltridge, G. W.
70-71:02K-021

Pande, H. K.
70-71:02I-007

Pandya, A. C.
70-71:04A-011

Pangborn, R. M.
70-71:05F-002

Papendick, R. I.
70-71:03F-006

Parekh, C. J.
70-71:02F-029

Parizek, Richard R.
70-71:02G-041

Parks, C. L.
70-71:02K-008

Patterson, R. M.
70-71:03F-027

Paulson, W. H.
70-71:05E-001

Peck, A. J.
70-71:02F-061

Peterson, C. P.
70-71:02F-005

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70-71:02E-002

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70-71:02I-012

Philip, J. R.
70-71:01B-002
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70-71:08D-004

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70-71:01B-001
70-71:02G-003

Phillips, S. H.
70-71:02G-003

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70-71:02D-006

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70-71:02G-080

Pinder, G. F.
70-71:02F-035

Pitman, M. G.
70-71:02K-043

Podmore, T. H.
70-71:02E-014

Pontin, J. M. A.
70-71:04B-002

Porcella, Donald B.
70-71:05C-002

Potter, E. C.
70-71:05G-022

Poulovassilis, A.
70-71:02G-016
70-71:02G-064

Power, J. F.
70-71:03F-022
70-71:03F-031
70-71:03F-037

Pratt, B. J.
70-71:02G-043

Pratt, P. F.
70-71:02K-031
70-71:02K-032

Preiss, K.
70-71:08D-002

Prill, Robert
70-71:02F-026

Pritchett, E. E.
70-71:06E-002

Pritchett, S.
70-71:06E-002

Qasim, Syed R.
70-71:05A-002

Quirk, J. P.
70-71:02G-086

Raabe, Edward W.
70-71:05B-016

Raats, P. A. C.
70-71:02G-036
70-71:02G-044
70-71:02K-035

Raguse, C. A.
70-71:03F-024

Rai, S. D.
70-71:03F-021

Ransford, G. D.
70-71:04B-001

Rasmussen, P. E.
70-71:03F-026

Rawlins, S. L.
70-71:02G-056
70-71:03C-001

Reeve, Ronald C.
70-71:04D-002

Reid, G. W.
  70-71:06E-002

Rekers, Robert G.
  70-71:05B-002

Remson, Irwin
  70-71:02G-002
  70-71:02G-028
  70-71:02G-029
  70-71:02I-002

Reuss, J. O.
  70-71:02K-006
  70-71:02K-007

Rex, R. W.
  70-71:02K-034

Reynolds, S. G.
  70-71:02G-038
  70-71:02G-039
  70-71:02G-040

Rhoads, F. M.
  70-71:03F-019

Ricca, V. T.
  70-71:04C-001

Rickard, D. S.
  70-71:02F-033
  70-71:02G-050

Rinot, M.
  70-71:03C-003

Robb, David C. N.
  70-71:03F-010

Robbins, C. W.
  70-71:05B-019

Robertson, George W.
  70-71:03F-012

Robinson, A. R.
  70-71:05B-031

Robinson, J. B.
  70-71:02K-042

Rochester, E. W., Jr.
  70-71:02F-053

Rogerson, T. L.
  70-71:02E-005

Rogowski, A. S.
  70-71:02G-045

Rollins, Myron B.
  70-71:04A-001

Romero, John C.
  70-71:05B-008

Rosenberg, Norman J.
  70-71:07B-003

Rothermel, T. W.
  70-71:06A-001

Russell, J. D.
  70-71:05C-001

Sachs, M. S.
  70-71:06A-001

Sainty, G. R.
  70-71:02D-015

Saulmon, R. W.
  70-71:02F-032

Saunders, W. M. H.
  70-71:02K-019

Saveson, I. L.
  70-71:02E-001

Sawhney, B. L.
  70-71:02K-036

Schneider, J. L.
  70-71:02F-060

Schoeberl, La Vern S.
  70-71:02I-001

Schuck, E. A.
  70-71:02I-016

Scott, V. H.
  70-71:05B-013

Scotter, D. R.
  70-71:02K-035

Seginer, Ido
  70-71:02D-009
  70-71:02G-025
  70-71:04A-027

Seidel, D. F.
  70-71:05D-001

Sevenhuysen, R. J.
  70-71:02F-024

Sewell, J. I.
  70-71:02E-013
  70-71:02G-080

Shah, A. M.
  70-71:04A-034

Sharapahov, N. N.
  70-71:06A-006

Shaw, R. H.
  70-71:02I-004
  70-71:02I-005

Shaykewich, C. F.
  70-71:02G-046

Shih, C. C.
  70-71:04A-037

Shipley, H.
  70-71:04A-009

Shmueli, M.
  70-71:03C-002
  70-71:03C-003

Siddoway, F. H.
  70-71:03F-028

Sievers, D. M.
  70-71:05B-049

Simmons, P. W.
  70-71:04C-001

Simpson, E. C.
  70-71:05B-011

Sims, James R.
  70-71:02D-011

Singh, Rameshwar
  70-71:04A-004

Sisson, D. R.
  70-71:04A-022

Skaggs, R. W.
  70-71:02G-007

Skogerboe, Gaylord V.
  70-71:05G-015

Smith, M. R.
  70-71:04A-043

Smith, R. A.
  70-71:04A-007

Smith, R. E.
  70-71:02G-014

Somerhalder, B. R.
  70-71:04A-045

Sonnichsen, J. C.
  70-71:05B-012

Sorey, M. L.
  70-71:02F-007

Sowell, R. S.
  70-71:04A-042

Specht, A. W.
  70-71:02I-017

Splinter, W. E.
  70-71:02D-022

Sree Ramulu, U. S.
70-71:02K-031
70-71:02K-032

Stapleton, H. N.
70-71:02I-014
70-71:02I-020

Stegman, E. C.
70-71:04A-034
70-71:04A-035

Sternberg, Yaron M.
70-71:02F-003

Stetson, L. E.
70-71:04A-038

Steyn, P. L.
70-71:02G-083

Stolzy, L. H.
70-71:02K-010
70-71:02K-011
70-71:02K-012
70-71:02K-022

Stuart, D. M.
70-71:02D-007

Sunada, D. K.
70-71:02F-028
70-71:02G-049

Swaine, D. J.
70-71:02F-060

Sweeten, J. M.
70-71:04A-039

Swoboda, A. R.
70-71:02K-030
70-71:05B-017

Sword, Bryan R.
70-71:05D-007
70-71:05D-008

Syers, J. K.
70-71:02K-034

Taiganides, Paul E.
70-71:04C-001

Tajchman, S. J.
70-71:02D-003

Takakura, T.
70-71:02I-011

Talsma, T.
70-71:01B-002

Tanji, K. K.
70-71:02G-063

Tankersley, E. L.
70-71:02G-090
70-71:03F-029
70-71:04B-036

Tanner, C. B.
70-71:02D-008
70-71:02D-014
70-71:02F-030

Tardiff, R. G.
70-71:05F-003

Tauxe, G. W.
70-71:02F-008
70-71:02F-023
70-71:06A-005

Taylor, A. W.
70-71:05B-011

Taylor, C.
70-71:02F-029

Taylor, H. M.
70-71:03F-057

Ter Haar, G.
70-71:02I-015

Terkeltoub, Richard W.
70-71:03C-005

Terman, G. L.
70-71:02K-016

Thomas, Grant W.
70-71:02K-030
70-71:05B-017

Thomas, J. R.
70-71:02G-004

Thomas, Richard E.
70-71:05D-002

Thompson, T. L.
70-71:04A-038

Thony, Jean-Louis
70-71:02G-024

Tibbs, Nicholas H.
70-71:05A-010

Timmons, D. R.
70-71:05B-014

Todorovic, P.
70-71:02A-002

Toksoz, Sadik
70-71:02G-009
70-71:02G-010

Topp, G. C.
70-71:02G-023

T h, J.
70-71:02A-003

Trabue, I. M.
70-71:05F-002

Trescott, P. C.
70-71:02F-035

Tunzi, Milton G.
70-71:05D-013

Turk, L. J.
70-71:02D-005

Turner, F., Jr.
70-71:03F-033

United States Department of Agriculture
70-71:05B-029

United States Environmental Protection Agency
70-71:05C-014
70-71:05C-015

Vachaud, Georges
70-71:02G-024

Vaidyanathan, L. V.
70-71:02G-061
70-71:02K-020

van Bavel, C. H. M.
70-71:02G-019
70-71:04A-031

Van der Waarden, M.
70-71:05B-018

Venetis, C.
70-71:02F-022
70-71:04A-003

Verma, A. P.
70-71:02F-018

Verma, B. P.
70-71:02G-081

Verruijt, A.
70-71:05B-015

Verstraeten, L. M. J.
70-71:02G-071

Viets, F. G., Jr.
70-71:05B-032

Vincent, J. R.
70-71:05C-001

Vlassak, K.
70-71:02G-071

Vomocil, J. A.
70-71:08D-005

Voropayev, G. V.
70-71:03F-060

Wade, R. M., & Company
70-71:03F-061
70-71:04A-047

Wadleigh, C. H.
70-71:05B-033

Waite, William P.
70-71:07B-002

Waldron, L. J.
70-71:02K-027

Walker, J. N.
70-71:02D-022

Walker, T. W.
70-71:02K-034

Wallace, D. E.
70-71:02K-003

Warner, Richard W.
70-71:05B-016

Warrick, A. W.
70-71:02G-022

Watson, W. S., Jr.
70-71:04A-028

Webber, L. R.
70-71:05B-034

Webster, R. G.
70-71:03C-017

Weinaug, Charles F.
70-71:02F-026

Weisman, Richard N.
70-71:02G-026

Welch, N. W.
70-71:04D-001

Wells, B. R.
70-71:02K-023

Wells, Dan M.
70-71:05B-002
70-71:06D-001

Werkhoven, C. H. E.
70-71:02K-005

Wesner, G. M.
70-71:05D-003

West, D. W.
70-71:02F-040

Whisler, Frank D.
70-71:02G-037

White, A. W.
70-71:02K-008

White, N. F.
70-71:02G-049

Wiebenga, William A.
70-71:02F-019

Wierenga, P. J.
70-71:02G-001
70-71:02G-017

Willardson, L. S.
70-71:02G-042
70-71:02G-058
70-71:05G-001
70-71:08A-001

Willatt, S. T.
70-71:03F-018

Willey, C. R.
70-71:02K-013

Williams, Dennis E.
70-71:04B-003

Williams, J. D. H.
70-71:02K-034

Williams, John
70-71:02G-046

Williams, J. R.
70-71:02E-009

Williamson, R. E.
70-71:02D-002
70-71:03F-008

Williford, John W.
70-71:05D-012
70-71:05F-001

Willis, W. O.
70-71:03F-022
70-71:03F-031

Willson, R. J.
70-71:04A-006

Wilson, D. O.
70-71:05B-021

Windsor, J. S.
70-71:04A-013

Winkworth, R. E.
70-71:02G-051

Winton, Elliott F.
70-71:05C-003
70-71:05F-003

Witherow, Jack L.
70-71:05B-048

Witherspoon, Paul A.
70-71:02G-030

Witzel, S. A.
70-71:05B-023
70-71:05E-001

Wolff, Roger G.
70-71:02F-014

Wood, I. R.
70-71:01B-005

Wooding, R. A.
70-71:01B-004

Woodward, G.
70-71:04A-041

Woody, W. M.
70-71:03F-006

Woolhiser, D. A.
70-71:02G-014

World Irrigation
70-71:03F-070

Wright, J. L.
70-71:02G-043
70-71:03F-015

Wu, I-pai
70-71:02G-088
70-71:03F-034
70-71:03F-067
70-71:04A-008

Yaron, Dan
70-71:03F-009

Yeh, William Wen-Gong
70-71:02F-008
70-71:02F-023
70-71:04A-004
70-71:06A-005

Young, K. G.
70-71:03A-001

Youngs, E. G.
70-71:02F-009
70-71:04A-002

Zwerman, P. J.
70-71:05B-021

SECTION XXXIX

SUBJECT INDEX

Absorption
    70-71:02G-004
    70-71:02G-022
    70-71:02G-046
    70-71:02K-013
    70-71:02K-017
    70-71:03F-022

Acid mine water
    70-71:03C-005

Adsorption
    70-71:05B-001
    70-71:05B-025

Advection
    70-71:02D-001
    70-71:02D-003

Aeration
    70-71:02G-051
    70-71:02K-012
    70-71:02K-013
    70-71:02K-022
    70-71:02G-053
    70-71:03F-008
    70-71:03F-013
    70-71:05G-001

Aggregates
    70-71:02G-005

Agricultural Chemicals
    70-71:05A-001
    70-71:05B-030
    70-71:05B-032
    70-71:05B-049
    70-71:05B-057

Agricultural Engineering
    70-71:02G-009
    70-71:02G-010
    70-71:04A-011
    70-71:04A-013

Agricultural runoff
    70-71:05B-040

Agricultural waste
    70-71:05B-022
    70-71:05D-006
    70-71:05D-007
    70-71:05D-010
    70-71:05D-011
    70-71:05D-012

Agricultural watersheds
    70-71:02A-001
    70-71:04D-001

Agriculture
    70-71:03C-004
    70-71:03F-008
    70-71:04C-001

Agriculture (Cont.)
    70-71:05F-001
    70-71:06D-002
    70-71:06E-001

Agronomic crops
    70-71:03F-004

Agronomy
    70-71:03F-009

Air pollution
    70-71:02I-015
    70-71:02I-016
    70-71:02I-017
    70-71:05B-057

Aldrin
    70-71:05B-001

Alfalfa
    70-71:02G-073
    70-71:03F-021
    70-71:03F-036
    70-71:05B-026

Algae
    70-71:05C-002
    70-71:05C-004
    70-71:05D-012

Alluvial channels
    70-71:04D-001

Alluvium
    70-71:02K-003

Anerobic bacteria
    70-71:05D-001
    70-71:05D-012

Anerobic conditions
    70-71:02K-032

Anerobic digestion
    70-71:05D-001

Anerobic treatment
    70-71:05D-006
    70-71:05D-007

Analog computers
    70-71:04A-009

Analog models
    70-71:02F-002
    70-71:02F-003
    70-71:04D-002
    70-71:08A-001

Analytic techniques
    70-71:02G-038
    70-71:02G-039
    70-71:05A-004

Analytic techniques (Cont.)
    70-71:05A-005
    70-71:05A-006
    70-71:05A-010
    70-71:06B-001

Animal growth
    70-71:02K-040
    70-71:02K-041

Animal metabolism
    70-71:02K-040
    70-71:02K-041

Animal pathology
    70-71:02K-040
    70-71:02K-041

Animal wastes
    70-71:05B-033
    70-71:05B-034

Anion exchange
    70-71:02K-030
    70-71:05D-009

Anisotropy
    70-71:02F-053
    70-71:02G-030

Antecedent precipitation
    70-71:02G-027

Appalachian Mountain Region
    70-71:05B-011

Application equipment
    70-71:04A-031
    70-71:05A-039

Application methods
    70-71:02K-015
    70-71:03C-009
    70-71:03C-010
    70-71:03C-011
    70-71:03C-012
    70-71:03F-033
    70-71:04A-017
    70-71:04A-039
    70-71:05E-001

Application rate
    70-71:02K-023
    70-71:03F-033

Approximation method
    70-71:02F-005

Aquatic animals
    70-71:05B-026

Aquatic habitats
70-71:05C-016

Aquatic life
70-71:05A-001

Aqueous solutions
70-71:01B-001
70-71:01B-003
70-71:02F-016
70-71:02G-022
70-71:02K-004
70-71:05B-009

Aquicludes
70-71:02F-004
70-71:02F-009

Aquifer characteristics
70-71:02F-001
70-71:02F-002
70-71:02F-003
70-71:02F-011
70-71:02F-020
70-71:02F-021
70-71:02K-001
70-71:03C-006
70-71:04B-002
70-71:06A-005

Aquifer testing
70-71:02F-035
70-71:02G-006

Aquifers
70-71:02A-003
70-71:02F-010
70-71:02F-013
70-71:02F-019
70-71:02F-022
70-71:02F-023
70-71:02F-027
70-71:02F-028
70-71:02F-029
70-71:02G-030
70-71:04B-002
70-71:04B-003
70-71:05B-007

Aquitards
70-71:02F-014

Arable land
70-71:04A-017

Arctic
70-71:07B-002

Arid lands
70-71:03C-002
70-71:03C-003
70-71:03F-001
70-71:03F-002

Arizona
70-71:02F-001
70-71:02K-003
70-71:03F-001

Artesian wells
70-71:03C-006

Artificial recharge
70-71:05D-003
70-71:05D-005

Atlantic coastal plain
70-71:05D-005

Atmometer
70-71:02D-012

Automatic control
70-71:03F-011
70-71:04A-009
70-71:04A-019
70-71:08C-002

Automation
70-71:02I-001
70-71:-3F-011
70-71:04A-010
70-71:04A-022
70-71:04A-026
70-71:04A-038
70-71:04A-039
70-71:04A-045
70-71:04A-047
70-71:07B-003
70-71:08A-002

Available water
70-71:02D-021
70-71:03F-044

Average costs
70-71:04A-005
70-71:06D-003

Bacteria
70-71:02K-018
70-71:05B-008

Barley
70-71:02K-007
70-71:03F-033
70-71:05C-007

Barrier
70-71:02K-008

Base flow
70-71:02E-003
70-71:02F-010
70-71:08A-001

Beans
70-71:02G-053
70-71:02I-019
70-71:05B-026

Bedload
70-71:01B-005

Benefit-cost ratios
70-71:03C-004

Benefits
70-71:06D-001

Bentonite
70-71:02F-025
70-71:04A-001

Bermudagrass
70-71:03F-057

Bibliographies
70-71:02G-037
70-71:03C-004
70-71:05C-006

Bioassay
70-71:05D-013

Biochemical oxygen
demand
70-71:05A-001

Biochemistry
70-71:02K-040
70-71:02K-041
70-71:02K-042
70-71:02K-043

Biodegradation
70-71:05B-004
70-71:05C-005
70-71:05G-001

Biological treatment
70-71:05D-010
70-71:05D-011

Biological uptake
70-71:02G-047
70-71:02I-006

Biological uptake roots
70-71:02K-013

Biology
70-71:01B-002
70-71:02K-040
70-71:02K-041
70-71:02K-042
70-71:02K-043

Blankets
70-71:04A-001

Border irrigation
70-71:02G-012
70-71:03F-007
70-71:04A-037
70-71:04A-039

Borehole geophysics
70-71:02F-007

Boreholes
70-71:02G-006

Boron
70-71:02G-063
70-71:02K-015
70-71:05A-004
70-71:05D-008

Bottom sediments
70-71:05C-002

Boundary layers
70-71:02F-012

Boundary processes
70-71:02F-009

Brackis water
70-71:06A-001

Brine disposal
70-71:03C-004

Brines
70-71:02D-005
70-71:02H-001

Bulk density
70-71:02G-005
70-71:02G-033
70-71:07B-006

Burried membranes
70-71:04A-001

Cadmium
70-71:02I-017

Calcium
70-71:02K-020
70-71:02K-029
70-71:05C-003
70-71:05F-002

Calibrations
70-71:02G-006

California
70-71:05B-007
70-71:05C-005
70-71:05D-003
70-71:05F-001
70-71:05F-004

Canal design
70-71:04A-009
70-71:08A-001
70-71:08A-003

Canal lining
70-71:04A-018

Canals
70-71:02F-009
70-71:08A-001

Canal seepage
70-71:02F-009
70-71:02G-012
70-71:08A-001

Capillary action
70-71:02G-013
70-71:02G-021

Capillary conductivity
70-71:02G-035
70-71:02G-037

Capillary pressure
70-71:02G-048

Capillary tubes
70-71:02G-037

Capillary water
70-71:04A-002

Carbonate rocks
70-71:02K-001

Carbonates
70-71:02F-039
70-71:03F-004
70-71:05A-002
70-71:05F-002

Carbon dioxide
70-71:05C-005

Carbon radioisotopes
70-71:02F-036

Cation exchange
70-71:02K-030
70-71:02K-036

Cation exchange
capacity
70-71:02K-020
70-71:02G-072

Casings
70-71:04B-003

Cereal crops
70-71:03F-001

Channel erosion
70-71:04D-001

Chemical analysis
70-71:02F-033
70-71:02K-005
70-71:02K-019
70-71:05B-001

Chemical compounds
70-71:03F-020

Chemical oxygen demand
70-71:05A-001

Chemical properties
70-71:02I-007
70-71:03F-025
70-71:05C-003

Chemical reactions
70-71:05C-022

Chemicals
70-71:02F-058
70-71:05B-025

Chemical wastes
70-71:05B-030

Chloride
70-71:02D-007
70-71:02G-022
70-71:02K-002
70-71:02K-030
70-71:05A-006
70-71:05B-010
70-71:05F-002

Chlorinated hydrocarbon
pesticides
70-71:05B-049

Chlorine
70-71:05F-002

Clay minerals
70-71:05B-003
70-71:07B-005

Clays
70-71:02F-025
70-71:02G-008
70-71:04A-001
70-71:05B-017

Climates
70-71:02A-003
70-71:02G-040
70-71:02G-050

Climatic data
70-71:03F-029
70-71:04A-034
70-71:06A-003

Climatology
70-71:03F-012

Clovers
70-71:02G-073

Cobalt radioisotopes
70-71:07B-005

Coefficients
70-71:02G-012

Coliforms
70-71:05B-010

Colloids
70-71:05A-005
70-71:05B-003

Colorado
70-71:02F-007
70-71:02J-002

Colorimetry
70-71:05A-004

Communication
70-71:04A-007

Comparative costs
70-71:06A-001

Competition
70-71:03F-002

Computer
70-71:02F-029
70-71:04A-013

Computer analysis
70-71:02K-012

Computer models
70-71:02D-022
70-71:02E-012
70-71:02F-020
70-71:02F-026
70-71:02G-019
70-71:02G-063
70-71:02G-074
70-71:02G-081
70-71:02G-090
70-71:02I-011
70-71:02I-013
70-71:02I-014
70-71:02I-020
70-71:02I-021
70-71:02I-022
70-71:04A-034
70-71:06A-001
70-71:06A-003

Computer programming
70-71:02D-006

Computer programs
70-71:02A-001
70-71:02D-006
70-71:02F-010
70-71:02F-013
70-71:02G-011
70-71:02G-013
70-71:02G-018
70-71:02G-035
70-71:02G-043
70-71:03F-023
70-71:03F-067
70-71:04A-004
70-71:05B-012
70-71:05B-013
70-71:05D-004
70-71:06A-005

Conduction
70-71:02G-001
70-71:02G-017

Conductivity
70-71:05B-007
70-71:07B-007

Confined water
70-71:03C-006
70-71:06A-005

Confinement pens
70-71:05B-010

Conservation
70-71:04A-010

Constraints
70-71:06D-002

Construction
70-71:04A-005
70-71:04A-006

Construction costs
70-71:04A-001

Construction equipment
70-71:04A-005

Construction methods
70-71:04A-005

Construction practices
70-71:04A-005

Consumptive use
70-71:02D-004
70-71:02D-006
70-71:02D-014
70-71:03F-029
70-71:03F-036
70-71:03F-057
70-71:04C-002

Consumptive use (water)
70-71:03C-004
70-71:03F-003
70-71:03F-018
70-71:03F-022

Continuity equation
70-71:02F-005

Continuous grazing
70-71:03F-024

Contour farming
70-71:04A-028

Convection
70-71:02D-003
70-71:02F-017
70-71:02F-061
70-71:02G-017
70-71:05B-012
70-71:05B-013

Copper
70-71:05A-010

Cores
70-71:02G-038
70-71:02G-039

Corn
70-71:02D-013
70-71:02G-003
70-71:02I-001
70-71:02I-003
70-71:02I-004
70-71:02I-005
70-71:03F-003
70-71:03F-027
70-71:05B-023
70-71:05C-007

Corn belt
70-71:02I-001

Correlation analysis
70-71:02J-002

Corrosion
70-71:05G-022

Cost analysis
70-71:05D-012
70-71:06C-001

Cost comparison
70-71:04A-005
70-71:05C-007

Costs
70-71:03C-004
70-71:04A-001
70-71:04A-010
70-71:05C-001
70-71:05F-001
70-71:06C-002
70-71:06C-003
70-71:06D-001

Cost sharing
70-71:06C-002

Cotton
70-71:02I-006
70-71:02I-008
70-71:02I-014
70-71:02I-020
70-71:02K-005
70-71:02K-015
70-71:03C-001
70-71:03F-005
70-71:03F-038

Crop growth
70-71:02G-090
70-71:02I-021
70-71:04A-042
70-71:04A-043

Crop production
70-71:02G-076
70-71:02I-001
70-71:02I-015
70-71:02I-016
70-71:02I-017
70-71:02I-020
70-71:02K-005
70-71:03C-002

- Crop production (Cont.)
  - 70-71:03C-004
  - 70-71:03C-009
  - 70-71:03C-010
  - 70-71:03C-011
  - 70-71:03C-012
  - 70-71:03F-001
  - 70-71:03F-002
  - 70-71:03F-044
  - 70-71:03F-045
  - 70-71:03F-047
  - 70-71:04A-017
  - 70-71:04A-022
  - 70-71:04A-047
  - 70-71:05E-001
  - 70-71:06A-004
- Crop response
  - 70-71:02D-008
  - 70-71:02G-003
  - 70-71:02I-012
  - 70-71:02K-015
  - 70-71:02K-023
  - 70-71:03C-003
  - 70-71:03F-001
  - 70-71:03F-004
  - 70-71:03F-009
  - 70-71:03F-013
  - 70-71:03F-020
  - 70-71:03F-024
  - 70-71:03F-026
- Crop rotation
  - 70-71:05B-021
- Crops
  - 70-71:02D-002
  - 70-71:02D-003
  - 70-71:03F-008
  - 70-71:03F-015
  - 70-71:06D-002
- Cycling nutrients
  - 70-71:05B-014
  - 70-71:05C-004
- Damages
  - 70-71:05C-001
- Dams
  - 70-71:02F-009
  - 70-71:02G-030
- Darcy's law
  - 70-71:02F-013
  - 70-71:02F-025
  - 70-71:02F-030
  - 70-71:02F-054
  - 70-71:02F-058
  - 70-71:02G-019
  - 70-71:02G-036
  - 70-71:02G-044
- Data collection
  - 70-71:02E-001
  - 70-71:02F-020
  - 70-71:05A-005
  - 70-71:05B-011
- Data processing
  - 70-71:02F-027
  - 70-71:05B-009
  - 70-71:06A-005
- DDT
  - 70-71:05B-001
  - 70-71:05B-017
- Decision making
  - 70-71:03F-017
- Demineralization
  - 70-71:03C-004
- Denitrification
  - 70-71:05B-022
  - 70-71:05D-001
  - 70-71:05D-006
  - 70-71:05D-009
  - 70-71:05D-012
  - 70-71:05D-013
  - 70-71:05F-001
  - 70-71:05G-001
- Density
  - 70-71:02F-017
  - 70-71:03F-002
  - 70-71:05B-015
  - 70-71:08D-002
- Deposition (sediments)
  - 70-71:04D-007
- Depth
  - 70-71:04A-005
- Desalination
  - 70-71:03A-001
  - 70-71:03C-004
  - 70-71:05D-008
  - 70-71:06A-001
- Desalination process
  - 70-71:03A-001
  - 70-71:03C-004
- Desalinization apparatus
  - 70-71:02D-020
- Deserts
  - 70-71:03C-002
- Design
  - 70-71:04A-011
  - 70-71:04A-034
  - 70-71:07B-003
- Design criteria
  - 70-71:03F-007
  - 70-71:03F-067
- Detention reservoirs
  - 70-71:04D-001
- Deuterium
  - 70-71:02F-006
- Dieldrin
  - 70-71:05B-001
- Diffusion
  - 70-71:01B-001
  - 70-71:02A-002
  - 70-71:02F-016
  - 70-71:02F-061
  - 70-71:02G-026
  - 70-71:02G-061
  - 70-71:02G-081
  - 70-71:02K-004
  - 70-71:02K-011
  - 70-71:02K-012
  - 70-71:02K-020
  - 70-71:02K-022
  - 70-71:05B-003
  - 70-71:05B-009
  - 70-71:05B-012
  - 70-71:05B-013
- Diffusivity
  - 70-71:02A-002
  - 70-71:02F-008
  - 70-71:02F-014
  - 70-71:02G-019
  - 70-71:02G-089
  - 70-71:07B-007
- Digital computers
  - 70-71:02G-029
  - 70-71:02G-030
  - 70-71:03F-010
  - 70-71:04A-009
  - 70-71:04B-003
- Diseases
  - 70-71:05F-003
- Discharge
  - 70-71:02A-003
  - 70-71:02E-002
  - 70-71:02F-015
  - 70-71:02G-048
  - 70-71:02H-001
  - 70-71:02K-003
  - 70-71:02K-004
  - 70-71:05B-009
- Discharge measurement
  - 70-71:02E-003
- Dispersion
  - 70-71:02A-002
  - 70-71:02F-012
  - 70-71:02F-016
  - 70-71:02F-017
  - 70-71:02G-086
  - 70-71:02G-087
  - 70-71:02K-003
  - 70-71:02K-004
  - 70-71:05B-009
  - 70-71:05B-013
  - 70-71:05B-015
- Disposal
  - 70-71:05A-001

Dissolved oxygen
    70-71:02K-004
    70-71:05B-009
    70-71:05C-001
    70-71:05D-012

Distillation
    70-71:03C-004

Distribution
    70-71:02K-005
    70-71:02K-018

Distribution patterns
    70-71:05B-017

Distribution systems
    70-71:03F-011
    70-71:03F-014
    70-71:03F-043
    70-71:03F-060
    70-71:04A-022
    70-71:04A-026
    70-71:04A-027
    70-71:04A-047

Ditches
    70-71:04A-003
    70-71:04A-026

Diurnal distribution
    70-71:02I-008

Domestic water
    70-71:05B-006
    70-71:05F-004

Drainage
    70-71:02F-004
    70-71:02F-028
    70-71:02F-029
    70-71:02F-030
    70-71:02F-032
    70-71:02F-052
    70-71:02F-053
    70-71:02F-054
    70-71:02F-058
    70-71:02G-005
    70-71:02G-028
    70-71:02G-037
    70-71:02G-048
    70-71:02G-049
    70-71:02G-063
    70-71:02G-074
    70-71:02G-075
    70-71:02K-013
    70-71:03F-013
    70-71:03F-057
    70-71:04A-002
    70-71:04A-006
    70-71:04B-001

Drainage density
    70-71:02J-002

Drainage effects
    70-71:03F-013
    70-71:05B-032

Drainage engineering
    70-71:02F-052
    70-71:02G-011
    70-71:02G-037

Drainage patterns (geologic)
    70-71:02J-002

Drainage systems
    70-71:02F-013
    70-71:02F-052
    70-71:04A-002
    70-71:04A-003
    70-71:04A-004
    70-71:05G-001

Drainage water
    70-71:05F-001

Drainage wells
    70-71:02F-013

Drains
    70-71:04A-005
    70-71:08A-001

Drain spacing
    70-71:04A-005

Drain tiles
    70-71:04A-005

Drawdown
    70-71:02F-002
    70-71:02F-003
    70-71:02F-011
    70-71:02F-013
    70-71:02F-021
    70-71:02F-027
    70-71:02G-006
    70-71:04A-002
    70-71:04A-003
    70-71:04A-004
    70-71:04B-002
    70-71:05G-001

Drops (fluids)
    70-71:02G-005

Drought
    70-71:03F-003

Dry farming
    70-71:03F-005

Drying
    70-71:02F-026
    70-71:02G-016

Dupuit-Forchheimer theory
    70-71:02F-004
    70-71:02F-008
    70-71:02F-009
    70-71:02F-019
    70-71:04A-004

Dust storms
    70-71:04A-025

Dye releases
    70-71:02F-016

Dynamic programming
    70-71:02I-013
    70-71:04A-013
    70-71:06A-002
    70-71:06A-003

Ecology
    70-71:05C-016
    70-71:06E-002

Economic efficiency
    70-71:06A-002
    70-71:06D-003
    70-71:06E-001

Economic feasibility
    70-71:03A-001

Economic impact
    70-71:03C-017
    70-71:05C-001

Economic prediction
    70-71:06D-002

Economics
    70-71:01B-002
    70-71:03C-017
    70-71:06C-001
    70-71:06C-002
    70-71:06D-001

Electrical conductance
    70-71:02E-003
    70-71:02K-026
    70-71:05A-006
    70-71:05A-007
    70-71:07B-004

Electrical equipment
    70-71:04A-038

Electric powerplants
    70-71:05B-055

Electric power production
    70-71:05B-055

Electrochemistry
    70-71:05A-006

Electrodes
    70-71:05A-006

Electrodialysis
    70-71:02A-001
    70-71:05D-008
    70-71:06A-001

Electrolysis
    70-71:05G-022

Energy balance
  70-71:02D-009

Energy budget
  70-71:02D-003

Energy conversion
  70-71:02I-021

Energy losses
  70-71:02E-002

Energy transfer
  70-71:01B-003

Engineering
  70-71:04A-007
  70-71:04A-021

Entomology
  70-71:05B-026

Environment
  70-71:02G-056

Environmental effects
  70-71:02D-008
  70-71:02D-010
  70-71:02I-012
  70-71:02K-040
  70-71:02K-041
  70-71:02K-042
  70-71:02K-043
  70-71:03F-001
  70-71:03F-002
  70-71:02F-015
  70-71:03F-017
  70-71:05A-009
  70-71:05B-032
  70-71:05G-016

Ephemeral streams
  70-71:02F-001

Equations
  70-71:02A-003
  70-71:02F-005
  70-71:02F-009
  70-71:02F-012
  70-71:02F-013
  70-71:02F-023
  70-71:02G-005
  70-71:02G-007
  70-71:02G-009
  70-71:02G-012
  70-71:02G-026
  70-71:02G-031
  70-71:02G-037
  70-71:04A-003
  70-71:04B-001
  70-71:05B-013

Equipment
  70-71:03C-002
  70-71:07B-003

Equitable apportionment
  70-71:06C-003

Erosion
  70-71:02A-004
  70-71:02E-009
  70-71:02E-014
  70-71:02I-001
  70-71:04D-001
  70-71:05B-001
  70-71:05B-003
  70-71:05B-031
  70-71:05B-040

Erosion control
  70-71:02J-003
  70-71:04A-025
  70-71:04A-028
  70-71:04D-001

Essential nutrients
  70-71:05C-004

Estimating
  70-71:02F-002
  70-71:02F-003
  70-71:02F-005
  70-71:02G-008
  70-71:02G-045
  70-71:06A-002

Estimating equations
  70-71:02E-001
  70-71:06D-002

Estuaries
  70-71:01B-005

Estuarine environment
  70-71:05C-016

Ethics
  70-71:04A-007

Eutrophication
  70-71:05B-011
  70-71:05B-014
  70-71:05C-002
  70-71:05C-004
  70-71:05D-013

Evaluation
  70-71:02D-008

Evaporation
  70-71:02D-005
  70-71:02D-008
  70-71:02D-012
  70-71:02D-014
  70-71:02D-015
  70-71:02D-019
  70-71:02D-021
  70-71:-2D-015
  70-71:-2F-030
  70-71:-2G-001
  70-71:02G-017
  70-71:02G-024
  70-71:02G-032
  70-71:03F-018
  70-71:03F-057
  70-71:04A-025

Evaporation (Cont.)
  70-71:04A-027
  70-71:05A-002
  70-71:05D-002

Evaporation control
  70-71:02D-012
  70-71:02G-032
  70-71:02I-003

Evaporation pans
  70-71:02D-005

Evaporimeter
  70-71:02D-011

Evapotranspiration
  70-71:02D-001
  70-71:02D-002
  70-71:02D-003
  70-71:02D-006
  70-71:02D-007
  70-71:02D-008
  70-71:02D-012
  70-71:02D-013
  70-71:02D-014
  70-71:02F-012
  70-71:02F-030
  70-71:02G-020
  70-71:02G-032
  70-71:02G-040
  70-71:02G-043
  70-71:02G-051
  70-71:02I-022
  70-71:03F-010
  70-71:03F-036
  70-71:03F-057
  70-71:04C-002
  70-71:05A-002
  70-71:05D-002
  70-71:07B-003

Evapotranspiration control
  70-71:02D-004

Excess water
  70-71:03F-044

Excess water (soils)
  70-71:02A-001

Experimental forms
  70-71:02D-008

Experimental farm
  70-71:02D-020

Extraction
  70-71:02G-002

Fallowing
  70-71:02K-009

Farm lagoons
  70-71:05B-034

Farm management
70-71:04A-001
70-71:04A-042
70-71:04A-043

Farms
70-71:05B-011

Farm wastes
70-71:05A-001
70-71:05A-003
70-71:05B-002
70-71:05B-007
70-71:05B-010
70-71:05B-011
70-71:05B-024
70-71:05B-034
70-71:05E-001

Feed lots
70-71:05B-034

Fertility
70-71:02I-004
70-71:02I-005
70-71:05E-001

Fertilization
70-71:02D-018
70-71:02I-007
70-71:03F-031
70-71:05B-022
70-71:05B-024
70-71:05B-032

Fertilizers
70-71:02G-004
70-71:02G-054
70-71:02K-006
70-71:02K-007
70-71:02K-008
70-71:02K-017
70-71:-3C-002
70-71:03F-027
70-71:05A-001
70-71:05B-007
70-71:05B-011
70-71:05B-019
70-71:05B-020
70-71:05B-023
70-71:05B-033
70-71:05B-049
70-71:05G-015

Fiber crops
70-71:02I-014

Field capacity
70-71:02G-048

Field investigations
70-71:04A-005

Field tests
70-71:04A-001
70-71:04A-005

Filters
70-71:02F-032
70-71:02F-052
70-71:04D-002
70-71:05D-001

Filtration
70-71:02F-032
70-71:05B-008
70-71:05D-005

Financing
70-71:06C-002

Fish
70-71:05A-001
70-71:05C-016

Fisheries
70-71:05C-016

Fish kill
70-71:05B-049

Flash distillation
70-71:03A-001
70-71:06A-001

Flood control
70-71:04A-028
70-71:04C-003

Flooding
70-71:03C-005

Florida
70-71:03C-006

Flow
70-71:02F-012
70-71:02F-017
70-71:02F-019
70-71:02F-021
70-71:02F-055
70-71:02F-061
70-71:02G-028
70-71:02I-002
70-71:05B-013
70-71:05B-015
70-71:07B-004

Flowering
70-71:03F-001

Flow measurement
70-71:08A-001

Flows nets
70-71:02F-012
70-71:02G-009
70-71:02G-010
70-71:02K-003

Flow rates
70-71:02G-007

Flow resistance
70-71:02E-002

Flow system
70-71:02F-055
70-71:05G-002

Fluid mechanics
70-71:02G-021
70-71:04A-035

Flumes
70-71:02E-002

Fluorometry
70-71:05D-013

Foliar application
70-71:02K-015

Forecasting
70-71:05G-016
70-71:06A-001
70-71:06C-003
70-71:06E-002

Forests
70-71:02D-003
70-71:05B-011

Fractures (geology)
70-71:02F-018

Free surfaces
70-71:02G-030

Frost action
70-71:04A-021

Frost protection
70-71:04A-021

Furrow drainage
70-71:02E-013
70-71:04A-008

Furrow irrigation
70-71:02G-084
70-71:03C-002
70-71:04A-001
70-71:04A-008
70-71:04A-012
70-71:04A-019
70-71:04A-026
70-71:04A-039
70-71:04A-045

Furrows
70-71:03F-005
70-71:04A-011

Furrow systems
70-71:04A-012

Gamma rays
70-71:02G-024
70-71:02G-033
70-71:08D-002

Garbage dumps
70-71:05A-002
70-71:05B-004

Gates
70-71:05A-009
70-71:04A-010

Geochemistry
70-71:02F-060
70-71:02K-001
70-71:05A-010

Geological surveys
70-71:06A-006

Geology
70-71:02A-003
70-71:02G-050

Geomorphology
70-71:02J-002

Geophysics
70-71:02F-066

Geothermal studies
70-71:02F-007

Germination
70-71:02G-046
70-71:03F-028

Glacial drift
70-71:05B-010

Grains (crops)
70-71:03F-001
70-71:03F-002

Grain sorghum
70-71:02D-001
70-71:02I-003
70-71:03F-038

Granular materials
70-71:02G-016

Graphical methods
70-71:03F-034

Grassed water ways
70-71:08A-003

Grasses
70-71:03F-020

Grasslands
70-71:02F-015

Gravimetric analysis
70-71:02G-038
70-71:02G-039

Gravimetry
70-71:02G-038
70-71:02G-039

Grazing
70-71:03F-024

Great Lakes
70-71:02K-002

Great Plains
70-71:03F-005

Greenhouses
70-71:02D-020
70-71:02I-011
70-71:05E-001

Groundwater
70-71:02E-005
70-71:02F-033
70-71:02F-035
70-71:02F-036
70-71:02F-040
70-71:02F-054
70-71:02F-060
70-71:02F-061
70-71:02G-009
70-71:02G-010
70-71:02K-025
70-71:02K-027
70-71:02K-028
70-71:02K-030
70-71:03C-009
70-71:03C-010
70-71:03C-011
70-71:03C-012
70-71:03F-045
70-71:03F-047
70-71:04A-004
70-71:04B-003
70-71:04C-001
70-71:05A-003
70-71:05B-007
70-71:05B-010
70-71:05B-047
70-71:05G-001
70-71:08A-001

Groundwater basins
70-71:02F-006
70-71:02F-010
70-71:02F-020
70-71:05B-047

Groundwater irrigation
70-71:02F-028

Groundwater movements
70-71:02A-002
70-71:02A-003
70-71:02F-001
70-71:02F-002
70-71:02F-003
70-71:02F-004
70-71:02F-005
70-71:02F-006
70-71:02F-007
70-71:02F-008
70-71:02F-009
70-71:02F-010
70-71:02F-011

Groundwater movements
(Cont.)
70-71:02F-012
70-71:02F-013
70-71:02F-014
70-71:02F-015
70-71:02F-016
70-71:02F-017
70-71:02F-018
70-71:02F-019
70-71:02F-020
70-71:02F-021
70-71:02F-022
70-71:02F-023
70-71:02F-024
70-71:02F-025
70-71:02F-026
70-71:02F-027
70-71:02F-028
70-71:02F-036
70-71:02F-039
70-71:02F-059
70-71:02G-011
70-71:02G-012
70-71:02G-018
70-71:02G-027
70-71:02G-029
70-71:02G-030
70-71:02G-064
70-71:02H-001
70-71:02K-001
70-71:02K-003
70-71:02K-037
70-71:03C-001
70-71:04A-002
70-71:04A-003
70-71:04B-001
70-71:05B-004
70-71:05B-006
70-71:05B-008
70-71:05B-015
70-71:05C-005
70-71:05D-005
70-71:07B-004
70-71:07B-005

Groundwater recharge
70-71:02F-001
70-71:02G-020
70-71:05B-018
70-71:05D-003

Groundwater resources
70-71:02F-096

Growth
70-71:02G-056
70-71:02K-021

Growth chambers
70-71:02D-020
70-71:02I-012

Growth rates
70-71:02I-012
70-71:02I-013
70-71:03F-002
70-71:03F-020

Growth rates (Cont.)
70-71:03F-033
70-71:05C-006

Growth stages
70-71:03F-001
70-71:03F-002
70-71:03F-021

Gypsum
70-71:03F-003

Hardness (water)
70-71:05C-033

Headloss
70-71:04A-030
70-71:04A-044

Heat
70-71:01B-003

Heat balance
70-71:02G-040

Heat budget
70-71:02G-040

Heat flow
70-71:02D-003
70-71:02F-007

Heat transfer
70-71:02D-003
70-71:02F-037
70-71:02F-044
70-71:02G-017

Heavy metals
70-71:05A-010

Herbicides
70-71:05B-002

Histograms
70-71:03F-014

Horticultural crops
70-71:02D-008

Hudson River
70-71:05C-016

Human diseases
70-71:05C-003

Human pathology
70-71:05C-003

Humidity
70-71:03C-001

Humus
70-71:05B-016

Hydraulic conductivity
70-71:02F-009
70-71:02F-014

Hydraulic conductivity (Cont.)
70-71:02F-016
70-71:02F-019
70-71:02F-042
70-71:02F-054
70-71:02F-058
70-71:02G-006
70-71:02G-007
70-71:02G-008
70-71:02G-016
70-71:02G-018
70-71:02G-020
70-71:02G-021
70-71:02G-024
70-71:02G-035
70-71:02G-036
70-71:02G-037
70-71:02G-044
70-71:02G-045
70-71:02G-046
70-71:02G-064
70-71:02G-084
70-71:02G-088
70-71:02I-002
70-71:02K-027
70-71:02K-028
70-71:04A-004

Hydraulic gradients
70-71:02F-004
70-71:02F-010
70-71:02F-022
70-71:02F-025
70-71:02G-020
70-71:04A-044

Hydraulic models
70-71:02A-002
70-71:02E-002
70-71:02F-016
70-71:02F-017
70-71:02F-024
70-71:02G-014
70-71:02G-021
70-71:02G-034
70-71:02G-036
70-71:02J-007
70-71:04D-002
70-71:05B-018
70-71:07B-004

Hydraulics
70-71:02E-002
70-71:04A-044

Hydrodynamics
70-71:02F-016

Hydroelectric plants
70-71:05C-016

Hydrogen
70-71:02K-020

Hydrogen ion concentrations
70-71:03C-005

Hydrogeology
70-71:02A-003
70-71:02F-001
70-71:02F-002
70-71:02F-003
70-71:02F-006
70-71:02F-010
70-71:02F-012
70-71:02F-013
70-71:02F-014
70-71:02F-019
70-71:02F-020
70-71:02K-001
70-71:03C-006
70-71:05D-005

Hydrographs
70-71:02F-008

Hydrograph analysis
70-71:02G-014
70-71:02J-002
70-71:04C-003

Hydrologic budget
70-71:02A-003
70-71:02D-005
70-71:02F-015
70-71:02K-002
70-71:03F-012
70-71:05D-002

Hydrologic cycle
70-71:02A-004
70-71:02D-019

Hydrologic data
70-71:02F-027
70-71:04C-001

Hydrologic systems
70-71:02A-004

Hydrology
70-71:02A-004
70-71:02D-006
70-71:02E-012
70-71:02F-001
70-71:02F-029
70-71:02F-037
70-71:02F-036
70-71:02F-044
70-71:02G-057
70-71:02G-087
70-71:02K-044
70-71:04C-001

Hydrostatic pressure
70-71:02F-025
70-71:08D-004

Hysteresis
70-71:02F-011
70-71:02G-016
70-71:02G-023
70-71:02G-024
70-71:02G-031
70-71:02G-064

Idaho
70-71:05B-019

Ice
70-71:04A-021

Illinois
70-71:05A-003

Immiscibility
70-71:02F-018

Impact (rainfall)
70-71:02G-025
70-71:02G-034
70-71:02J-001

Impaired water quality
70-71:03C-005

Incubation
70-71:02K-014
70-71:02K-016

Indicators
70-71:05A-007

Infiltration
70-71:02A-001
70-71:02F-005
70-71:02F-011
70-71:02F-015
70-71:02F-021
70-71:02F-022
70-71:02F-024
70-71:02F-051
70-71:02F-058
70-71:02G-004
70-71:02G-007
70-71:02G-012
70-71:02G-013
70-71:02G-014
70-71:02G-017
70-71:02G-018
70-71:02G-019
70-71:02G-020
70-71:02G-021
70-71:02G-022
70-71:02G-023
70-71:02G-024
70-71:02G-025
70-71:02G-026
70-71:02G-027
70-71:02G-029
70-71:02G-034
70-71:02G-035
70-71:02G-037
70-71:02G-041
70-71:02G-045
70-71:02G-057
70-71:02G-058
70-71:02G-088
70-71:03F-009
70-71:03F-034
70-71:03F-044
70-71:04A-003
70-71:04A-030
70-71:04A-037

Infiltration (Cont.)
70-71:04A-041
70-71:05D-005

Infiltration rates
70-71:02G-062
70-71:02G-068
70-71:02G-075

Infiltrometers
70-71:02G-012

Inflow
70-71:04A-011

Infrared radiation
70-71:02G-080
70-71:07B-001

Inhibition
70-71:05C-006

Injection wells
70-71:02F-018
70-71:05D-003

Inorganic compounds
70-71:02G-052
70-71:02G-071
70-71:02G-083
70-71:02I-009
70-71:02I-018
70-71:02K-025
70-71:02K-027
70-71:02K-028
70-71:02K-029
70-71:02K-030
70-71:02K-031
70-71:02K-032
70-71:02K-035
70-71:02K-036
70-71:02K-039

Input-Output analysis
70-71:02G-019

Insecticides
70-71:05B-017
70-71:05B-049

Instrumentation
70-71:02D-011
70-71:02F-007
70-71:02G-020
70-71:02G-031
70-71:02G-033
70-71:02G-041
70-71:02G-042
70-71:02G-080
70-71:07B-003
70-71:07B-004

Interfaces
70-71:05B-015

Investigations
70-71:02F-015
70-71:06A-006

Investment
70-71:03C-004
70-71:06D-003

Ion exchange
70-71:02F-025
70-71:05B-003
70-71:05B-005

Ions
70-71:02K-003
70-71:02K-020
70-71:05A-006

Ion transport
70-71:01B-001
70-71:02F-025
70-71:02G-011
70-71:02G-022
70-71:02G-063
70-71:02K-003
70-71:07B-004

Ion uptake
70-71:02G-061

Iron
70-71:03C-005
70-71:03F-019
70-71:05B-016

Iron oxides
70-71:02K-031

Irrigation
70-71:02D-009
70-71:02F-033
70-71:02G-001
70-71:02G-012
70-71:02G-049
70-71:02G-057
70-71:02G-068
70-71:02G-079
70-71:02I-008
70-71:02K-005
70-71:03F-001
70-71:03F-009
70-71:03F-015
70-71:03F-016
70-71:03F-017
70-71:03F-024
70-71:03F-029
70-71:03F-034
70-71:03F-037
70-71:03F-038
70-71:03F-042
70-71:04A-006
70-71:04A-007
70-71:04A-008
70-71:04A-009
70-71:04A-010
70-71:04A-011
70-71:04A-012
70-71:04A-021
70-71:05A-001
70-71:05B-033
70-71:05C-015
70-71:05G-020

Irrigation (Cont.)
70-71:06A-002
70-71:06B-001
70-71:06D-001
70-71:06C-002
70-71:06E-001

Irrigation canals
70-71:03F-014
70-71:04A-001
70-71:04A-018

Irrigation design
70-71:02G-058
70-71:03G-002
70-71:03F-007
70-71:03F-010
70-71:03F-011
70-71:04A-026
70-71:04A-030
70-71:04A-041
70-71:04A-045

Irrigation efficiency
70-71:02G-043
70-71:02G-090
70-71:03C-002
70-71:03C-003
70-71:03F-007
70-71:03F-009
70-71:03F-010
70-71:03F-014
70-71:03F-029
70-71:03F-034
70-71:03F-044
70-71:03F-045
70-71:03F-047
70-71:03F-054
70-71:03F-068
70-71:03F-069
70-71:03F-070
70-71:04A-008
70-71:04A-017
70-71:04A-045

Irrigation effects
70-71:02G-053
70-71:02I-013
70-71:03C-002
70-71:03F-019
70-71:03F-068
70-71:05B-048
70-71:05C-015
70-71:05G-014
70-71:05G-020

Irrigation engineering
70-71:02G-074
70-71:02G-075
70-71:02G-082
70-71:02G-090
70-71:03C-002
70-71:03C-009
70-71:03C-010
70-71:03C-011
70-71:03C-012
70-71:03F-007
70-71:03F-010

Irrigation engineering (Cont.)
70-71:03F-011
70-71:03F-054
70-71:03F-065
70-71:03F-069
70-71:04A-009
70-71:04A-017
70-71:04A-025
70-71:04A-026
70-71:04A-028
70-71:04A-031
70-71:04A-034
70-71:04A-039
70-71:04A-041
70-71:04A-044
70-71:04A-045
70-71:08C-002

Irrigation operation
70-71:04A-009

Irrigation operation & maintenance
70-71:03F-007

Irrigation operation & management
70-71:03F-060

Irrigation practices
70-71:02G-069
70-71:02G-075
70-71:02G-079
70-71:02G-084
70-71:02G-088
70-71:02G-090
70-71:03F-010
70-71:03F-014
70-71:03F-034
70-71:03F-038
70-71:03F-043
70-71:03F-044
70-71:03F-045
70-71:03F-047
70-71:03F-054
70-71:03F-060
70-71:03F-065
70-71:03F-067
70-71:03F-068
70-71:03F-069
70-71:03F-070
70-71:04A-009
70-71:04A-019
70-71:04A-021
70-71:04A-020
70-71:04A-026
70-71:04A-027
70-71:04A-030
70-71:04A-031
70-71:04A-034
70-71:04A-035
70-71:04A-037
70-71:04A-038
70-71:04A-039
70-71:04A-041
70-71:04A-045
70-71:04A-047

Irrigation practices (Cont.)
70-71:05B-022
70-71:05B-040
70-71:08A-002

Irrigation programs
70-71:02G-043
70-71:02G-090
70-71:03F-045
70-71:03F-047
70-71:03F-070
70-71:06A-003

Irrigation soil moisture
70-71:02G-054

Irrigation structures
70-71:08A-002

Irrigation systems
70-71:02G-058
70-71:02G-079
70-71:03C-002
70-71:03C-003
70-71:03C-009
70-71:03C-010
70-71:03C-011
70-71:03C-012
70-71:03F-007
70-71:03F-010
70-71:03F-014
70-71:03F-043
70-71:03F-060
70-71:04A-009
70-71:04A-013
70-71:04A-017
70-71:04A-019
70-71:04A-027
70-71:04A-031
70-71:04A-038
70-71:04A-039
70-71:04A-041
70-71:04A-044
70-71:04A-045
70-71:08C-002

Irrigation water
70-71:02G-012
70-71:02G-017
70-71:02G-031
70-71:02G-032
70-71:02G-041
70-71:03C-002
70-71:03C-004
70-71:03C-005
70-71:03F-012
70-71:05B-007
70-71:05B-019
70-71:05B-026
70-71:05C-015
70-71:05D-004
70-71:05D-006
70-71:05D-007
70-71:05D-008
70-71:05G-015
70-71:05G-020

Irrigation water (Cont.)
70-71:06D-002

Irrigation wells
70-71:05B-026

Isotopy
70-71:02F-013

Karst
70-71:05B-004

Koalinite
70-71:02D-004

Laboratory tests
70-71:02F-014
70-71:02F-015
70-71:02F-017
70-71:02G-016
70-71:02G-031
70-71:02G-032
70-71:02G-034
70-71:02G-038
70-71:02G-039
70-71:02G-049
70-71:03C-001
70-71:05B-001
70-71:05D-001
70-71:05F-002
70-71:07B-005
70-71:08A-001

Lagoons
70-71:05D-004

Lakes
70-71:02H-001
70-71:05B-002
70-71:05C-002

Laminar flow
70-71:02E-002
70-71:02G-021

Land
70-71:03F-042

Landfills
70-71:02G-041
70-71:05A-002
70-71:05B-004
70-71:05C-005

Land forming
70-71:02E-013

Land management
70-71:02E-013
70-71:02J-003
70-71:03F-031
70-71:04C-003
70-71:05B-024
70-71:06B-002

Land use
70-71:04C-001
70-71:04C-002

Land use (Cont.)
70-71:04C-003
70-71:06B-002

Laplaces equation
70-71:04B-001

Leaching
70-71:02D-007
70-71:02F-024
70-71:02G-011
70-71:02G-041
70-71:02G-063
70-71:02G-069
70-71:02K-003
70-71:02K-004
70-71:02K-009
70-71:02K-030
70-71:03F-044
70-71:05A-002
70-71:05B-004
70-71:05B-011
70-71:05B-014
70-71:05B-016
70-71:05B-017
70-71:05B-018
70-71:05B-019
70-71:05B-025
70-71:05B-032
70-71:05B-040
70-71:05B-049
70-71:05C-002

Leaching translocation
70-71:05B-005

Lead
70-71:02I-015
70-71:02I-016
70-71:02I-017
70-71:02I-018

Leakage
70-71:02F-028
70-71:02G-030

Least squares method
70-71:02F-023
70-71:06A-002

Leaves
70-71:03C-001
70-71:03F-019
70-71:03F-023

Legal aspects
70-71:03C-018
70-71:06E-001

Legislation
70-71:03C-018
70-71:06E-002

Legumes
70-71:02G-054

Lemons
70-71:03C-009

Lemons (Cont.)
70-71:03C-012

Limiting factors
70-71:03F-002

Limnology
70-71:05C-002

Light
70-71:02I-021

Light intensity
70-71:02D-004

Linear programming
70-71:02F-008
70-71:02F-020
70-71:02F-023
70-71:04A-004
70-71:04A-013
70-71:05B-013
70-71:06A-002
70-71:06A-004
70-71:06A-005
70-71:06D-002

Linings
70-71:04A-001

Livestock
70-71:05A-001

Loam
70-71:03F-007

Long-tube vertical distillation
70-71:06A-001

Louisiana
70-71:02E-001

Lysimeters
70-71:02D-019
70-71:02G-041
70-71:03F-013
70-71:04A-031
70-71:07B-003

Magnesium
70-71:02K-029
70-71:05C-003
70-71:05F-002

Maintenance
70-71:04A-006
70-71:04A-007
70-71:04A-010

Malenclaves
70-71:05B-006

Management
70-71:02K-044
70-71:02K-045
70-71:03C-017
70-71:03C-018
70-71:04B-003

Management (Cont.)
  70-71:06C-003

Management operation
  70-71:04A-007

Manganese
  70-71:03F-019
  70-71:05B-009
  70-71:05B-016

Manure & fertilizer applications
  70-71:05B-021

Mapping
  70-71:02G-080
  70-71:07B-001
  70-71:07B-002

Marginal costs
  70-71:06D-003

Marketing
  70-71:06C-001

Mass
  70-71:08D-002

Mass transfer
  70-71:02D-007
  70-71:02G-011
  70-71:02G-017
  70-71:02G-022
  70-71:05B-003

Mathematical models
  70-71:01B-004
  70-71:02A-002
  70-71:02A-003
  70-71:02D-009
  70-71:02D-022
  70-71:02E-002
  70-71:02E-009
  70-71:02E-012
  70-71:02F-001
  70-71:02F-002
  70-71:02F-003
  70-71:02F-005
  70-71:02F-008
  70-71:02F-010
  70-71:02F-014
  70-71:02F-015
  70-71:02F-016
  70-71:02F-018
  70-71:02F-020
  70-71:02F-023
  70-71:02F-026
  70-71:02F-028
  70-71:02F-055
  70-71:02F-061
  70-71:02G-006
  70-71:02G-014
  70-71:02G-018
  70-71:02G-019
  70-71:02G-021
  70-71:02G-022
  70-71:02G-025

Mathematical models (Cont.)
  70-71:02G-028
  70-71:02G-029
  70-71:02G-035
  70-71:02G-074
  70-71:02G-081
  70-71:02G-088
  70-71:02I-002
  70-71:02I-013
  70-71:02I-014
  70-71:02I-020
  70-71:02I-022
  70-71:02K-002
  70-71:02K-004
  70-71:04A-013
  70-71:04A-042
  70-71:04A-043
  70-71:04B-003
  70-71:04C-003
  70-71:05D-004
  70-71:06A-005
  70-71:06B-001
  70-71:07B-006

Mathematical studies
  70-71:02A-003
  70-71:02E-001
  70-71:02F-004
  70-71:02F-005
  70-71:02F-008
  70-71:02F-012
  70-71:02F-013
  70-71:02F-016
  70-71:02F-023
  70-71:02G-006
  70-71:02G-007
  70-71:02G-009
  70-71:02G-018
  70-71:02G-036
  70-71:02G-044
  70-71:02G-089
  70-71:03F-014
  70-71:04A-002
  70-71:04A-003
  70-71:04A-004
  70-71:05B-012
  70-71:05B-013

Mature growth stage
  70-71:03F-002

Measurement
  70-71:02D-015
  70-71:02D-019
  70-71:02G-015
  70-71:02G-080
  70-71:03F-023

Mechanical control
  70-71:03F-011

Melons
  70-71:03C-009
  70-71:03C-012

Membrane processes
  70-71:02F-025

Membrane processes (Cont.)
  70-71:03C-004
  70-71:05A-006

Metabolism
  70-71:02I-012
  70-71:02K-040
  70-71:02K-041
  70-71:05C-006

Metallurgy
  70-71:05G-022

Meteorological data
  70-71:02D-006

Meteorology
  70-71:04A-027

Meter
  70-71:02G-015

Methodology
  70-71:02G-007
  70-71:02G-037
  70-71:04A-001
  70-71:06B-001

Mexico
  70-71:02D-020

Michigan
  70-71:05D-004

Microbiology
  70-71:02G-083
  70-71:05B-026
  70-71:05C-006

Microclimatology
  70-71:02D-003

Micrometeorology
  70-71:02D-003

Microorganisms
  70-71:02G-083
  70-71:05C-006

Mine wastes
  70-71:05A-010

Mineral waters
  70-71:02F-039
  70-71:05F-002

Mining
  70-71:05A-010

Missouri
  70-71:05A-010

Mist irrigation
  70-71:04A-031

Mixing
  70-71:01B-004

Mixing (Cont.)
70-71:02F-006
70-71:02F-016
70-71:02F-017
70-71:02F-018
70-71:02H-001
70-71:02K-003
70-71:02K-004
70-71:05B-009
70-71:05B-012
70-71:05B-015
70-71:07B-004

Model
70-71:02G-051
70-71:02K-006
70-71:02K-007
70-71:02K-012
70-71:02K-021
70-71:03F-016
70-71:03F-017
70-71:03F-018
70-71:03F-038

Model studies
70-71:02A-002
70-71:02A-003
70-71:02D-002
70-71:02E-003
70-71:02F-014
70-71:02F-015
70-71:02F-016
70-71:02F-017
70-71:02F-020
70-71:02F-024
70-71:02G-027
70-71:02G-034
70-71:02G-069
70-71:02G-081
70-71:05B-018
70-71:06B-001
70-71:06D-002

Model study
70-71:02G-002
70-71:02G-005

Mohr envelope
70-71:02G-005

Moisture availability
70-71:02G-081
70-71:02I-002
70-71:03F-006

Moisture content
70-71:02G-003
70-71:02G-015
70-71:02G-016
70-71:02G-024
70-71:02G-033
70-71:02G-038
70-71:02G-039
70-71:02G-040
70-71:02I-002
70-71:02I-008
70-71:03F-021
70-71:08D-005

Moisture deficit
70-71:02I-004
70-71:02I-005
70-71:03F-018

Moisture stress
70-71:02G-054
70-71:02I-004
70-71:02I-005
70-71:02I-008
70-71:02K-040
70-71:02K-041
70-71:02K-042
70-71:02K-043
70-71:03F-001
70-71:03F-002
70-71:03F-003

Moisture tension
70-71:03F-006
70-71:03F-015
70-71:03F-023
70-71:03F-044

Moisture uptake
70-71:02G-037
70-71:02I-002
70-71:02I-006
70-71:03F-036

Molybdenum
70-71:02G-073

Monitoring
70-71:02G-041
70-71:05A-003
70-71:05A-005

Montana
70-71:04A-018

Monte Corlo method
70-71:03F-014

Mortality
70-71:05C-003

Municipal wastes
70-71:05D-009
70-71:05D-016

Mulch
70-71:02I-003
70-71:03F-027

Mulching
70-71:03F-005
70-71:04A-025

Multislage flash distillation
70-71:03C-004

National parks
70-71:03C-006

Natural recharge
70-71:02F-001

Nebraska
70-71:03F-047
70-71:07B-003

Nematodes
70-71:05B-026
70-71:05G-015

Nevada
70-71:02G-006

New Mexico
70-71:02F-007

New York
70-71:05C-016

Nickel
70-71:02I-017

Nitrates
70-71:05A-003
70-71:05A-006
70-71:05B-002
70-71:05B-007
70-71:05B-010
70-71:05B-011
70-71:05B-019
70-71:05B-022
70-71:05B-029
70-71:05D-006
70-71:05D-007
7--71:05D-008
70-71:05D-009
70-71:05D-010
70-71:05D-011
70-71:05D-012
70-71:05D-013
70-71:05F-001
70-71:05G-001
70-71:05G-015

Nitrification
70-71:02G-052
70-71:02G-083
70-71:02K-014

Nitrogen
70-71:02D-018
70-71:02G-004
70-71:02G-047
70-71:02G-052
70-71:02G-054
70-71:02K-006
70-71:02K-007
70-71:02K-008
70-71:02K-009
70-71:02K-016
70-71:02K-017
70-71:02K-023
70-71:03F-022
70-71:03F-027
70-71:05B-011
70-71:05B-014
70-71:05C-006
70-71:05D-013

Nitrogen compounds
70-71:02G-071
70-71:02G-083
70-71:05B-049
70-71:05C-006

Nitrogen cycle
70-71:02G-083
70-71:05C-006

Nitrogen fixation
70-71:02G-083

Nitrogen fixing bacteria
70-71:02G-083

Nonlinear systems
70-71:03F-014

Nozzles
70-71:03C-002

Nuclear meters
70-71:08D-002

Nuclear moisture meters
70-71:02E-005
70-71:02G-024
70-71:02G-031
70-71:02G-032
70-71:02G-033

Nuclear power plants
70-71:05B-055

Numerical analysis
70-71:02F-005
70-71:02F-008
70-71:02F-010
70-71:02F-023
70-71:02F-026
70-71:02F-028
70-71:02G-013
70-71:02G-014
70-71:02G-018
70-71:02G-019
70-71:02G-021
70-71:02G-022
70-71:02G-026
70-71:02G-035
70-71:02G-037
70-71:02G-089
70-71:05B-012
70-71:05B-013
70-71:05B-015

Numerical method
70-71:02G-037

Nutrients
70-71:02K-019
70-71:03F-025
70-71:05B-002
70-71:05B-010
70-71:05B-011
70-71:05B-014
70-71:05B-019
70-71:05B-020

Nutrients (Cont.)
70-71:05B-022
70-71:05B-023
70-71:05C-002
70-71:05C-004
70-71:05E-001

Nutrient removal
70-71:02K-005

Nutrient requirements
70-71:05C-004

Observation wells
70-71:02F-007
70-71:02F-014
70-71:02F-015

Odor
70-71:05D-003
70-71:05F-002

Ohio
70-71:05B-011

Oil water
70-71:05B-018

Oily water
70-71:05B-018

Onions
70-71:02D-008

On-site investigations
70-71:03F-005
70-71:08A-001

On-site tests
70-71:02F-014
70-71:02F-015
70-71:02F-026
70-71:02G-027
70-71:02G-038
70-71:02G-040
70-71:05A-005

Open channels
70-71:04A-035

Open channel flow
70-71:04A-035
70-71:05B-009
70-71:05B-013
70-71:08A-003

Operating costs
70-71:03C-004

Operations
70-71:04A-006

Operations research
70-71:04A-013

Optimization
70-71:02F-008
70-71:03F-014

Optimization (Cont.)
70-71:03F-016
70-71:03F-067
70-71:04A-008
70-71:04A-013
70-71:04B-003
70-71:04C-003
70-71:06A-002

Optimum development plans
70-71:06A-003

Optimum use
70-71:03F-014

Orchards
70-71:04A-021

Organic compounds
70-71:02K-034
70-71:05A-005

Organic matter
70-71:02K-032
70-71:05A-003
70-71:05B-016
70-71:05C-005

Organic soils
70-71:05B-016

Organic wastes
70-71:05D-016

Organizations
70-71:04A-006
70-71:04A-007

Osmosis
70-71:02F-025
70-71:03A-001

Osmotic pressure
70-71:03C-001

Overburden
70-71:08D-004

Overland flow
70-71:02E-002
70-71:02G-014
70-71:02G-027
70-71:05B-001
70-71:05B-002
70-71:05D-002

Oxidation
70-71:05G-022

Oxidation lagoons
70-71:05B-034

Oxygen
70-71:02F-006
70-71:02K-010
70-71:02K-011
70-71:02K-012

Oxygen (Cont.)
70-71:02K-022

Oxygen demand
70-71:05B-004

Paleocliniatology
70-71:02F-036

Palynology
70-71:02H-001

Pan evaporation
70-71:02D-011

Parametric hydrology
70-71:02F-008
70-71:02F-023
70-71:02G-014
70-71:04C-003
70-71:06A-005

Particle size
70-71:02F-019
70-71:02G-008
70-71:03F-001
70-71:05B-003
70-71:07B-006

Pasture
70-71:02K-021
70-71:03F-024

Path of pollutants
70-71:02G-022
70-71:02G-041
70-71:02K-001
70-71:05A-002
70-71:05A-003
70-71:05B-001
70-71:05B-003
70-71:05B-004
70-71:05B-005
70-71:05B-006
70-71:05B-008
70-71:05B-009
70-71:05B-010
70-71:05B-011
70-71:05B-012
70-71:05B-014
70-71:05B-015
70-71:05B-018
70-71:05B-019
70-71:05B-020
70-71:05B-025
70-71:05C-005

Peanuts
70-71:03F-025

Pennsylvania
70-71:02G-041
70-71:03C-005
70-71:05B-004

Percolating water
70-71:02F-054

Percolation
70-71:02F-012
70-71:02F-026
70-71:02G-017
70-71:02G-021
70-71:02G-022
70-71:02G-023
70-71:02G-024
70-71:02G-026
70-71:02G-030
70-71:02G-031
70-71:02G-032
70-71:02G-035
70-71:02G-036
70-71:02G-041
70-71:02G-063
70-71:02G-084
70-71:02G-088
70-71:02G-089
70-71:02K-018
70-71:04C-001
70-71:05A-002
70-71:05B-004
70-71:07B-004

Performance
70-71:02G-042

Perma frost
70-71:07B-002

Permeability
70-71:02F-002
70-71:02F-003
70-71:02F-013
70-71:02F-018
70-71:02F-019
70-71:02F-022
70-71:02F-027
70-71:02F-042
70-71:02F-051
70-71:02F-054
70-71:02F-058
70-71:02G-008
70-71:02G-012
70-71:02G-025
70-71:02G-034
70-71:02G-057
70-71:02G-068
70-71:02G-084
70-71:02G-088
70-71:02K-011
70-71:04A-004
70-71:04B-001
70-71:04B-002
70-71:07B-006

Permeameters
70-71:02G-024
70-71:02G-031
70-71:07B-006

Personnel
70-71:04A-006
70-71:04A-007

Pest control
70-71:05B-030

Pesticides
70-71:05B-001
70-71:05B-002
70-71:05B-005
70-71:05B-030
70-71:05B-033
70-71:05B-061

Pesticide removal
70-71:05B-061

Pesticide residues
70-71:05B-001
70-71:05B-005

Phosphate
70-71:02G-061
70-71:05B-020

Phosphates
70-71:05B-002
70-71:05B-011
70-71:05B-019
70-71:05B-022
70-71:05C-002
70-71:05G-015

Phosphorus
70-71:02G-004
70-71:02G-054
70-71:02K-034
70-71:03F-030
70-71:05B-014
70-71:05C-002

Phosphorus compounds
70-71:05B-049
70-71:05C-004

Photogrammetry
70-71:07B-001

Photosynthesis
70-71:02I-021

Piezometers
70-71:02F-014
70-71:02F-035

Pilot plants
70-71:05D-001

Pipes
70-71:03F-011

Pipe Flow
70-71:04A-030
70-71:04A-044

Pit recharge
70-71:02F-026

Planning
70-71:03F-009
70-71:04A-007
70-71:04B-003
70-71:06B-001
70-71:06C-002

Planning (Cont.)
70-71:06D-002
70-71:06D-003

Plant growth
70-71:02D-002
70-71:02G-082
70-71:02I-001
70-71:02I-003
70-71:02I-011
70-71:02I-012
70-71:02I-013
70-71:02I-014
70-71:02I-019
70-71:02I-022
70-71:02K-042
70-71:02K-043
70-71:03C-001
70-71:03F-001
70-71:03F-002
70-71:04C-031

Planting management
70-71:02D-013
70-71:02G-076
70-71:02I-001
70-71:03F-031

Plant pathology
70-71:02K-042
70-71:02K-043

Plant physiology
70-71:02I-021
70-71:02K-042
70-71:02K-043

Plant population
70-71:03F-002
70-71:03F-027

Plants
70-71:03F-008
70-71:03F-009
70-71:05B-014

Plastics
70-71:04A-018

Plastic pipes
70-71:04A-005

Playas
70-71:05B-002

Policy
70-71:04A-007

Pollutants
70-71:02E-009
70-71:02I-018
70-71:05A-001
70-71:05A-009
70-71:05B-024
70-71:05B-025
70-71:05B-048

Pollutant identification
70-71:05A-001
70-71:05A-004
70-71:05A-006
70-71:05A-007
70-71:05A-010

Pollution (soil)
70-71:02I-018

Pollution abatement
70-71:02G-014
70-71:05A-007
70-71:05A-009
70-71:05B-048
70-71:05B-057
70-71:05B-058
70-71:05C-014

Pollution effects
70-71:02I-015
70-71:02I-016
70-71:02I-017

Pollution sources
70-71:02I-015
70-71:02I-016
70-71:02I-017

Polyethelene
70-71:04A-005

Ponds
70-71:02F-026

Ponding
70-71:02G-034

Pore pressure
70-71:02G-049
70-71:02G-068
70-71:04B-001

Porosity
70-71:02F-019
70-71:02F-025
70-71:02G-021
70-71:02G-057
70-71:02K-011
70-71:07B-006

Porous materials
70-71:02G-016

Porous media
70-71:01B-004
70-71:02A-002
70-71:02E-002
70-71:02F-002
70-71:02F-009
70-71:02F-012
70-71:02F-016
70-71:02F-017
70-71:02F-018
70-71:02F-026
70-71:02F-042
70-71:02F-051

Porous media (Cont.)
70-71:02F-053
70-71:02F-054
70-71:02F-055
70-71:02F-058
70-71:02F-061
70-71:02G-013
70-71:02G-016
70-71:02G-019
70-71:02G-023
70-71:02G-028
70-71:02G-029
70-71:02G-030
70-71:02G-037
70-71:02G-049
70-71:04B-001
70-71:05B-008
70-71:05B-013
70-71:05B-015
70-71:07B-007

Potable water
70-71:05F-004

Potassium
70-71:02K-029
70-71:05B-001

Potential evapotranspiration
70-71:02D-010

Precipitation (atmospheric)
70-71:02F-015

Precipitation excess
70-71:02A-001
70-71:04C-003

Pressure head
70-71:02G-007
70-71:02G-036
70-71:02G-044

Pricing
70-71:06C-001
70-71:06C-002
70-71:06D-013

Productivity
70-71:03F-004
70-71:05C-002
70-71:05C-004

Projects
70-71:02D-008

Project benefits
70-71:04D-001

Projections
70-71:06D-001

Protective coatings
70-71:04A-001

Provenance
70-71:02F-006
70-71:02H-001

Public health
70-71:05A-002
70-71:05A-003
70-71:05C-003
70-71:05F-003

Public utilities
70-71:06C-001

Puddling
70-71:02G-034

Pumped storage
70-71:05C-016

Pumping
70-71:02F-013
70-71:02G-006
70-71:04B-003
70-71:06D-001

Radar
70-71:07B-002

Radiation
70-71:02D-012
70-71:08D-002

Radio
70-71:04A-010

Radioactivity techniques
70-71:07B-005

Radioisotopes
70-71:02F-019
70-71:02G-052
70-71:07B-005

Rainfall
70-71:02D-002
70-71:02G-040
70-71:02I-001
70-71:03F-006
70-71:03F-012
70-71:03F-038
70-71:04C-001
70-71:05B-020

Rainfall disposition
70-71:02G-034

Rainfall-runoff relationships
70-71:02E-003
70-71:02F-010
70-71:02G-014
70-71:02G-027
70-71:02J-002
70-71:03F-005
70-71:04C-002
70-71:04C-003

Rainfall simulator
70-71:05B-021

Rates
70-71:06C-001

Rates of application
70-71:02G-005

Recession curves
70-71:02H-014

Recharge
70-71:02F-011
70-71:02F-013
70-71:02F-015
70-71:02F-026
70-71:02G-024
70-71:02G-029
70-71:02K-003

Reclaimed water
70-71:02D-020
70-71:05D-003

Reclamation
70-71:04A-010

Recreation
70-71:05A-001

Reduction
70-71:04A-011

Reforestation
70-71:04C-001

Regime
70-71:02A-003

Regression analysis
70-71:05B-007

Regulation
70-71:06B-002

Relative humidity
70-71:02G-056

Reliability
70-71:02G-042

Remote control
70-71:04A-009

Remote sensing
70-71:02G-080
70-71:07B-002
70-71:09B-001

Research priorities
70-71:02K-045

Reservoir design
70-71:05B-016

Reservoir leakage
70-71:04A-001

Reservoirs
70-71:04A-001
70-71:04A-010
70-71:04B-003
70-71:05B-016

Resins
70-71:05D-009

Respiration
70-71:02I-002
70-71:02K-010
70-71:02K-011
70-71:02K-012
70-71:02K-022

Retardants
70-71:03F-020

Retention
70-71:02G-040

Return flow
70-71:05B-019
70-71:05C-015
70-71:05D-006
70-71:05D-007
70-71:05D-008
70-71:05G-020

Reverses osmosis
70-71:03A-001
70-71:05D-008
70-71:06A-001

Reviews
70-71:02F-006
70-71:02K-001
70-71:05B-008
70-71:05C-006

Reynolds Number
70-71:02E-002

Rice
70-71:02G-047
70-71:02I-007
70-71:02K-010
70-71:02K-023

Rill erosion
70-71:04A-028

Risks
70-71:03F-016
70-71:03F-017
70-71:06A-003
70-71:06B-001

River
70-71:05B-061

Root development
70-71:02G-053
70-71:03F-004
70-71:03F-008

Root distribution
70-71:03F-004

Root system
70-71:02G-002
70-71:02I-002
70-71:02K-010
70-71:02K-011
70-71:02K-022

Root zone
70-71:02D-007
70-71:02F-030
70-71:02G-040
70-71:02I-002
70-71:03F-028

Rotation
70-71:02K-014

Rotation grazing
70-71:03F-024

Roughness (hydraulic)
70-71:02E-002
70-71:04A-035
70-71:08A-003

Routing
70-71:02A-001
70-71:04C-003

Runoff
70-71:02A-004
70-71:02G-014
70-71:02I-001
70-71:03F-007
70-71:04A-012
70-71:04A-025
70-71:04A-028
70-71:04C-001
70-71:05B-002
70-71:05B-011
70-71:05B-014
70-71:05B-023
70-71:05D-002
70-71:05E-001
70-71:06B-002

Runoff forecasting
70-71:02A-001
70-71:02G-014
70-71:02J-002
70-71:04C-003

Safe yield
70-71:02F-010

Saline soils
70-71:02G-011
70-71:02G-084
70-71:02I-019
70-71:02K-026
70-71:02K-035
70-71:03C-002
70-71:03F-026
70-71:03F-033
70-71:05C-007

Saline water
70-71:01B-005
70-71:02G-033
70-71:03C-002
70-71:03C-003
70-71:03C-004
70-71:03C-006
70-71:05G-020

Saline water barriers
70-71:01B-004

Saline water - fresh-water interfaces
70-71:01B-004
70-71:02G-011
70-71:05B-015

Saline water intrusion
70-71:01B-004
70-71:02F-009
70-71:02F-016
70-71:02F-018
70-71:02K-001
70-71:05B-015

Saline water systems
70-71:01B-003
70-71:01B-004
70-71:02D-007
70-71:02H-001

Salinity
70-71:01B-002
70-71:01B-005
70-71:02A-004
70-71:02D-005
70-71:02F-019
70-71:02F-039
70-71:02F-061
70-71:02G-004
70-71:02G-020
70-71:02G-042
70-71:02G-056
70-71:02G-069
70-71:02G-086
70-71:02I-012
70-71:02K-019
70-71:02K-026
70-71:02K-041
70-71:02K-042
70-71:02K-043
70-71:02K-044
70-71:02K-045
70-71:02K-046
70-71:03C-002
70-71:03C-004
70-71:03C-006
70-71:03C-017
70-71:03C-018
70-71:03F-033
70-71:03G-015
70-71:05A-001
70-71:05A-004
70-71:05B-007
70-71:05B-019
70-71:05B-047
70-71:05C-001

Salinity (Cont.)
70-71:05C-015
70-71:05D-008
70-71:05G-022

Salinity meters
70-71:02G-042

Salts
70-71:01B-005
70-71:02G-022

Saltation
70-71:01B-005

Salt balance
70-71:02G-063
70-71:02K-002

Salt tolerance
70-71:02F-012
70-71:03C-011

Sampling
70-71:02G-008
70-71:02G-038
70-71:02G-039
70-71:02G-040
70-71:02G-041
70-71:03C-005
70-71:05A-003

Sands
70-71:02F-015
70-71:02G-008
70-71:04A-001
70-71:04D-002

Sanitary engineering
70-71:05B-008
70-71:05B-023
70-71:05D-016
70-71:06E-002

Saturated flow
70-71:02F-009
70-71:02F-010
70-71:02F-013
70-71:02F-015
70-71:02F-025
70-71:02F-042
70-71:02F-053
70-71:02F-054
70-71:02F-061
70-71:02G-024
70-71:02G-028
70-71:02G-029
70-71:02G-035
70-71:02G-037
70-71:02G-044
70-71:05G-001

Saturated soils
70-71:02I-012
70-71:03F-008
70-71:04D-002

Saturation
70-71:02F-055
70-71:02G-049

Scaling
70-71:03A-001

Scheduling
70-71:03F-016
70-71:03F-017
70-71:03F-029
70-71:06C-002

Sealants
70-71:04A-001

Seasonal
70-71:02G-040

Sediments
70-71:02E-009
70-71:02F-019
70-71:04D-001
70-71:05B-003
70-71:05B-031
70-71:05B-033

Sediment control
70-71:04A-025
70-71:04A-028
70-71:04D-002
70-71:05B-031

Sediment transport
70-71:04D-001
70-71:04D-002
70-71:05B-003
70-71:05B-031

Sediment yield
70-71:02J-002
70-71:04D-001
70-71:05B-003
70-71:05B-031

Sedimentation
70-71:02A-004
70-71:04D-001
70-71:04D-002
70-71:05B-031

Seeds
70-71:02D-008
70-71:02G-046
70-71:03F-001

Seepage
70-71:02F-009
70-71:02F-011
70-71:02F-029
70-71:02G-008
70-71:02G-009
70-71:02G-010
70-71:02G-012
70-71:03F-005
70-71:04A-001
70-71:05A-002
70-71:05B-008

Seepage losses
70-71:04A-018

Self-purification
70-71:05B-061

Semiarid climates
70-71:02I-001
70-71:03F-002
70-71:03F-005
70-71:06D-002

Semipermeable membranes
70-71:03A-001

Sensors
70-71:02G-042

Separation techniques
70-71:05A-005
70-71:05G-001

Settlement (structural)
70-71:02G-005

Sewage
70-71:05A-006
70-71:05D-004
70-71:05D-016
70-71:06E-001

Sewage disposal
70-71:05D-005
70-71:05D-016

Sewage treatment
70-71:05D-001
70-71:05D-002
70-71:05D-005

Sheet erosion
70-71:02C-014

Silts
70-71:02E-014
70-71:02G-008

Silting
70-71:04D-002

Similitude
70-71:02G-048

Simulated rainfall
70-71:02G-027
70-71:02H-034
70-71:02J-001

Simulation techniques
70-71:02E-003
70-71:02F-010
70-71:02F-020
70-71:02G-018
70-71:02G-021
70-71:02G-035
70-71:04B-003
70-71:04C-003
70-71:05D-004

Simulation techniques
(Cont.)
70-71:06A-002
70-71:06A-003
70-71:06A-005
70-71:06B-001

Slopes
70-71:02F-004
70-71:02G-040
70-71:03F-007

Small watersheds
70-71:02A-001

Snowmelt
70-71:02F-001
70-71:02F-015

Social aspects
70-71:01B-002
70-71:03C-017

Social impact
70-71:03C-017

Social participation
70-71:03C-017

Sodium
70-71:02K-041
70-71:03F-004
70-71:05F-002

Soils
70-71:02D-002
70-71:02F-033
70-71:02G-003
70-71:02G-004
70-71:02G-009
70-71:02G-010
70-71:02G-015
70-71:02G-037
70-71:02G-061
70-71:02G-072
70-71:03F-029
70-71:05B-001

Soil aggregates
70-71:02G-005
70-71:02K-018

Soil amendments
70-71:05B-024

Soil analysis
70-71:02F-060
70-71:02G-038
70-71:02G-039
70-71:02I-018
70-71:02K-019

Soil chemistry
70-71:01B-002
70-71:02D-007
70-71:02F-060
70-71:02F-061
70-71:02G-052

Soil chemistry (Cont.)
70-71:02G-073
70-71:02H-072
70-71:02H-086
70-71:02H-087
70-71:02I-018
70-71:02I-019
70-71:02K-025
70-71:02K-027
70-71:02K-028
70-71:02K-029
70-71:02K-030
70-71:02K-031
70-71:02K-032
70-71:02K-034
70-71:02K-035
70-71:02K-036
70-71:02K-044
70-71:05B-032
70-71:05E-001

Soil classifications
70-71:02G-072
70-71:07B-002

Soil compaction
70-71:02G-025
70-71:02J-001

Soil conservation
70-71:02C-014
70-71:02E-009
70-71:04A-025
70-71:04A-028
70-71:04C-003
70-71:04D-001
70-71:05B-040

Soil contamination
70-71:05B-005

Soil density
70-71:02G-086
70-71:02G-087
70-71:08D-002

Soil dispersants
70-71:02G-086
70-71:02G-087

Soil engineering
70-71:02G-016
70-71:02G-072

Soil environment
70-71:02F-019

Soil erosion
70-71:02F-001
70-71:02J-001
70-71:02J-003
70-71:04A-025
70-71:04A-028
70-71:04D-001
70-71:05B-001
70-71:05B-023

Soil gases
70-71:02G-071
70-71:03F-008
70-71:04D-002

Soil investigations
70-71:02G-072
70-71:07B-002

Soil management
70-71:02G-072
70-71:02G-087
70-71:02H-042
70-71:02H-062
70-71:02H-063
70-71:02H-072
70-71:02H-086
70-71:02J-003
70-71:02K-008
70-71:02K-009
70-71:02K-025
70-71:02K-027
70-71:02K-028
70-71:02K-029
70-71:02K-031
70-71:02K-032
70-71:02K-035
70-71:03F-031

Soil mechanics
70-71:02F-029
70-71:02G-005
70-71:02G-008
70-71:08D-004
70-71:08D-005

Soil moisture
70-71:01B-001
70-71:02D-008
70-71:02D-010
70-71:02D-021
70-71:02E-005
70-71:02F-011
70-71:02F-037
70-71:02F-040
70-71:02F-060
70-71:02G-005
70-71:02G-009
70-71:02G-015
70-71:02G-038
70-71:02G-039
70-71:02G-040
70-71:02G-041
70-71:02G-043
70-71:02G-045
70-71:02G-047
70-71:02G-050
70-71:02G-051
70-71:02G-053
70-71:02G-064
70-71:02G-068
70-71:02G-070
70-71:02G-074
70-71:02G-080
70-71:02G-081
70-71:02G-082
70-71:02G-085
70-71:02G-087

Soil moisture (Cont.)
70-71:02I-001
70-71:02I-002
70-71:02I-004
70-71:02I-005
70-71:02I-006
70-71:02K-030
70-71:02K-035
70-71:03F-001
70-71:03F-002
70-71:03F-004
70-71:03F-005
70-71:03F-006
70-71:03F-036
70-71:03F-038
70-71:04A-018
70-71:05A-003
70-71:07B-001
70-71:07B-002
70-71:07B-007
70-71:08D-005

Soil moisture meters
70-71:02G-015
70-71:02G-020
70-71:02G-024
70-71:02G-032
70-71:02G-033
70-71:02G-038
70-71:02G-039
70-71:03F-044

Soil physics
70-71:01B-002
70-71:02E-005
70-71:02F-037
70-71:02F-044
70-71:02F-051
70-71:02F-058
70-71:02G-045
70-71:02G-057
70-71:02G-069
70-71:02G-071
70-71:02G-074
70-71:02G-075
70-71:02G-081
70-71:02G-082
70-71:02G-083
70-71:02G-086
70-71:02G-087
70-71:03F-057
70-71:08D-005

Soil profile
70-71:02G-051

Soil properties
70-71:02F-051
70-71:02G-007
70-71:02G-008
70-71:02G-019
70-71:02G-024
70-71:02G-040
70-71:02G-044
70-71:02G-048
70-71:02G-062
70-71:02K-009
70-71:02K-026

Soil properties (Cont.)
70-71:02K-029
70-71:07B-002
70-71:08D-004

Soil salinity
70-71:05C-007

Soil science
70-71:02D-001
70-71:02G-016
70-71:02G-069
70-71:02G-072
70-71:02K-031
70-71:02K-032
70-71:07B-007

Soil sealants
70-71:04A-001

Soil stability
70-71:08D-005

Soil strength
70-71:08D-005

Soil surfaces
70-71:02G-025
70-71:02G-062
70-71:02J-001

Soil temperature
70-71:02F-037
70-71:02F-044
70-71:02G-001
70-71:02G-017
70-71:02I-001
70-71:02I-003
70-71:02K-014

Soil testing
70-71:02K-006
70-71:02K-007

Soil texture
70-71:02D-021
70-71:02G-005
70-71:02G-008
70-71:02G-025
70-71:02G-086
70-71:02G-087
70-71:02K-025
70-71:02K-027
70-71:02K-028
70-71:03C-002
70-71:03F-007

Soil water movement
70-71:02D-007
70-71:02F-009
70-71:02F-011
70-71:02F-025
70-71:02F-026
70-71:02F-051
70-71:02G-005
70-71:02G-006
70-71:02G-007
70-71:02G-008

Soil water movement (Cont.)
70-71:02G-009
70-71:02G-010
70-71:02G-011
70-71:02G-013
70-71:02G-018
70-71:02G-019
70-71:02G-020
70-71:02G-021
70-71:02G-022
70-71:02G-023
70-71:02G-024
70-71:02G-027
70-71:02G-029
70-71:02G-031
70-71:02G-032
70-71:02G-035
70-71:02G-036
70-71:02G-037
70-71:02G-041
70-71:02G-044
70-71:02G-045
70-71:02G-058
70-71:02G-060
70-71:02G-089
70-71:02I-002
70-71:04A-002
70-71:04A-004
70-71:05B-018
70-71:05D-002

Soil-water-plant relationships
70-71:02D-004
70-71:02D-007
70-71:02D-008
70-71:02D-021
70-71:02G-002
70-71:02G-017
70-71:02G-043
70-71:02G-082
70-71:02I-002
70-71:02I-012
70-71:02I-018
70-71:02J-002
70-71:03C-001
70-71:03C-003
70-71:03C-005
70-71:03F-001
70-71:03F-010
70-71:03F-013
70-71:03F-044
70-71:03F-057
70-71:04C-002
70-71:05B-014
70-71:06A-002
70-71:06A-003

Soil-water-plant system
70-71:05B-025

Solar radiation
70-71:02D-005
70-71:02G-040
70-71:07B-001

Solutes
70-71:02D-006
70-71:02D-007
70-71:02F-016
70-71:02K-003
70-71:02K-004
70-71:05A-005
70-71:05B-002
70-71:05B-004
70-71:05B-010
70-71:07B-004

Sorghum
70-71:03F-002

Sorption
70-71:02G-022
70-71:05B-003

South Dakota
70-71:02I-001

Soybean
70-71:02D-012
70-71:03F-023

Specific capacity
70-71:02F-011

Specific yield
70-71:02F-019
70-71:04A-004
70-71:04B-002

Sprays
70-71:04A-031

Springs
70-71:02F-039
70-71:02H-001

Sprinkler irrigation
70-71:02A-027
70-71:02G-005
70-71:02G-074
70-71:02G-075
70-71:03C-009
70-71:03C-011
70-71:03C-012
70-71:03F-067
70-71:04A-007
70-71:04A-017
70-71:04A-021
70-71:04A-022
70-71:04A-030
70-71:04A-031
70-71:04A-034
70-71:05D-002

Stable isotopes
70-71:02F-006

Stage-discharge relations
70-71:02F-008

Standards
70-71:05F-003

Standards (Cont.)
  70-71:05F-004
  70-71:06B-002

Statistical methods
  70-71:02A-002
  70-71:05B-007
  70-71:05B-011

Statistical model
  70-71:02A-002
  70-71:02D-010

Statistics
  70-71:02F-006

Steady flow
  70-71:02F-012
  70-71:02F-013
  70-71:02F-027
  70-71:02G-009
  70-71:02G-010
  70-71:02G-044

Stochastic processes
  70-71:02A-002
  70-71:02F-014

Stomata
  70-71:02D-008

Storage
  70-71:04B-003

Storage coefficient
  70-71:02F-002
  70-71:02F-003
  70-71:02F-014
  70-71:02F-022
  70-71:02F-027
  70-71:04B-002
  70-71:06A-005

Storms
  70-71:02E-001

Stratified flow
  70-71:02F-009

Streams
  70-71:04A-012
  70-71:05A-010

Stream flow
  70-71:02A-004
  70-71:02K-002
  70-71:-2K-004
  70-71:04C-001
  70-71:05B-009
  70-71:05B-012

Streamflow forecasting
  70-71:02J-002

Stream gages
  70-71:02E-003
  70-71:05A-007

Strontium radio isotopes
  70-71:03F-004

Structures
  70-71:06C-002

Submergence
  70-71:02I-007

Subsurface drainage
  70-71:02F-013
  70-71:02F-052
  70-71:02G-010
  70-71:02G-011
  70-71:02G-019
  70-71:02G-027
  70-71:02G-089
  70-71:04A-002
  70-71:04A-004
  70-71:04A-005
  70-71:04D-002
  70-71:05G-001
  70-71:08A-001

Subsurface irrigation
  70-71:02G-058
  70-71:03F-011
  70-71:03F-034
  70-71:04A-008
  70-71:04A-012
  70-71:04A-026

Subsurface water
  70-71:02F-030

Sugar beets
  70-71:05B-026

Sulfate
  70-71:05F-002

Supplemental irrigation
  70-71:03F-037
  70-71:03F-068

Surface drainage
  70-71:02E-013

Surface-groundwater relationships
  70-71:02F-008
  70-71:02F-010
  70-71:02F-011
  70-71:02F-026
  70-71:02G-034

Surface iffigation
  70-71:02D-009
  70-71:02G-079
  70-71:03F-060
  70-71:04A-019
  70-71:04A-037
  70-71:08A-002

Surface runoff
  70-71:02A-001
  70-71:02E-001

Surface runoff (Cont.)
  70-71:02E-12
  70-71:02J-001
  70-71:05B-020
  70-71:05B-021

Surface sealing
  70-71:02G-025
  70-71:02J-001

Surface waters
  70-71:02A-004
  70-71:02E-009
  70-71:05A-003
  70-71:05A-004

Surveys
  70-71:02F-006
  70-71:02F-015
  70-71:05A-003
  70-71:05B-007
  70-71:05B-008
  70-71:07B-001
  70-71:07B-002

Suspended load
  70-71:05B-003

Swamp
  70-71:02D-015

Sweet corn
  70-71:03C-009
  70-71:03C-012

Switch grass
  70-71:03F-032

Synthetic hydrology
  70-71:04C-003

Systems analysis
  70-71:02F-023
  70-71:02G-019
  70-71:03F-014
  70-71:04A-008
  70-71:04A-013
  70-71:05D-004
  70-71:06A-005
  70-71:06D-002

Tagging
  70-71:05D-003
  70-71:05F-002
  70-71:05F-004

Taste
  70-71:02A-002

Technology
  70-71:02K-044
  70-71:02K-045

Telemetry
  70-71:04A-010

Temperature
  70-71:01B-003

Temperature (Cont.)
70-71:02D-001
70-71:02D-008
70-71:02F-007
70-71:02K-016
70-71:03C-001
70-71:05F-002
70-71:07B-001

Temperature control
70-71:04A-021

Tensiometers
70-71:02G-024
70-71:03F-044

Tertiary treatment
70-71:05D-003
70-71:05D-005
70-71:05D-009

Test procedures
70-71:02G-038
70-71:02G-039

Texas
70-71:03F-005
70-71:05B-002

Theis equation
70-71:04B-002

Theoretical analysis
70-71:02G-037

Thermal solution
70-71:05B-055

Thermal powerplants
70-71:05B-055

Thermodynamics
70-71:01B-003
70-71:02F-037
70-71:02F-044
70-71:02K-001

Tile drainage
70-71:02F-052
70-71:02G-011
70-71:02G-074
70-71:05B-022

Tile drains
70-71:02G-011
70-71:04D-002
70-71:05D-008
70-71:05D-013

Tillage
70-71:02G-003
70-71:03F-028
70-71:03F-031

Time
70-71:02F-032
70-71:02G-005
70-71:03F-002

Time (Cont.)
70-71:06D-003

Time lag
70-71:02F-011
70-71:02G-064

Timing
70-71:-3F-010

Tobacco
70-71:02K-013
70-71:03F-017
70-71:03F-019

Tomatoes
70-71:03C-009
70-71:03C-012
70-71:03F-030

Topography
70-71:02G-050
70-71:02J-002

Toxicity
70-71:02I-018

Tracers
70-71:02A-002
70-71:02F-006
70-71:02F-012
70-71:02F-016
70-71:02F-019
70-71:02H-001
70-71:02K-003
70-71:05B-015
70-71:07B-004
70-71:07B-005

Trace elements
70-71:05C-003

Tracking techniques
70-71:02A-002
70-71:02F-006
70-71:02H-001

Translocation
70-71:02I-002
70-71:05B-012
70-71:05B-049
70-71:07B-005

Transmissivity
70-71:02F-002
70-71:02F-003
70-71:02F-019
70-71:02F-021
70-71:02F-022
70-71:02F-027
70-71:02G-006
70-71:04B-002
70-71:04B-003
70-71:06A-005

Transpirator
70-71:02D-014
70-71:02G-002

Transpirator (Cont.)
70-71:02I-002
70-71:02I-019
70-71:02I-021
70-71:03C-001
70-71:03F-057

Transpiration control
70-71:02D-004

Treatment
70-71:05D-010
70-71:05D-011

Turbidity
70-71:04D-001
70-71:05B-003

Turbulent flow
70-71:02E-002
70-71:05B-009
70-71:05B-012

Turf
70-71:02E-002

Turnouts
70-71:03F-007

Underseepage
70-71:02F-009

Uniform flow
70-71:02F-013

Uniformity coefficient
70-71:03F-007
70-71:04A-017

Unsaturated flow
70-71:02F-009
70-71:02F-015
70-71:02F-026
70-71:02F-061
70-71:02G-013
70-71:02G-018
70-71:02G-019
70-71:02G-022
70-71:02G-024
70-71:02G-028
70-71:02G-029
70-71:02G-031
70-71:02G-035
70-71:02G-036
70-71:02G-037
70-71:02G-044
70-71:02G-089
70-71:02I-002
70-71:05G-001
70-71:07B-007

Unsteady flow
70-71:02F-010
70-71:02F-023
70-71:02F-027
70-71:02G-014
70-71:02G-029
70-71:02G-035

Unsteady flow (Cont.)
70-71:02G-089
70-71:04A-004
70-71:04B-002
70-71:04B-012

Urbanization
70-71:05B-007

Use rates
70-71:06C-001
70-71:06C-003

Utilities
70-71:06C-001

Utah
70-71:02D-005

Value
70-71:06D-001

Vapor compression distillation
70-71:03A-001

Vapor pressure
70-71:02D-005

Variability
70-71:02G-040

Varieties
70-71:03F-032

Vegetation
70-71:02K-021

Vegetation effects
70-71:02G-034
70-71:02G-040
70-71:03F-002
70-71:07B-002

Velocity
70-71:02F-007
70-71:02F-012
70-71:02F-019
70-71:02I-002
70-71:04D-002
70-71:07B-004

Viruses
70-71:05B-008

Viscosity
70-71:02F-017
70-71:02F-018
70-71:02F-025
70-71:02G-064
70-71:05B-015

Waste dillution
70-71:05B-009

Waste disposal
70-71:05B-008
70-71:05B-034

Waste disposal (Cont.)
70-71:05C-005
70-71:05D-016

Waste disposal wells
70-71:05B-058

Waste treatment
70-71:05D-001
70-71:05D-002
70-71:05D-004
70-71:05D-016

Waste water
70-71:03F-054
70-71:03F-065
70-71:03F-069
70-71:04A-018
70-71:05B-048
70-71:05G-014

Waste water disposal
70-71:05D-002
70-71:05D-004

Waste water treatment
70-71:03A-001
70-71:05D-001
70-71:05D-012

Water
70-71:02D-014
70-71:02G-028
70-71:02G-041
70-71:02G-057
70-71:03F-036

Water allocation (policy)
70-71:03C-001
70-71:03F-012
70-71:06A-003
70-71:06A-004
70-71:06D-002

Water analysis
70-71:05A-002
70-71:05A-004
70-71:05A-005

Water balance
70-71:02D-002
70-71:02D-005
70-71:02D-008
70-71:02F-010
70-71:02F-015
70-71:02F-022
70-71:02K-002
70-71:03F-012
70-71:04C-002

Water chemistry
70-71:01B-001
70-71:01B-002
70-71:01B-005
70-71:02A-003
70-71:02A-004
70-71:02D-007

Water chemistry (Cont.)
70-71:02D-009
70-71:02E-003
70-71:02F-006
70-71:02F-060
70-71:02G-022
70-71:02H-001
70-71:02K-003
70-71:02K-040
70-71:02K-042
70-71:02K0043
70-71:02K-045
70-71:03C-005
70-71:03C-006
70-71:05B-006
70-71:05B-008
70-71:05B-016
70-71:05C-004

Water conservation
70-71:02D-004
70-71:02G-032
70-71:02I-001
70-71:03C-009
70-71:03C-010
70-71:03C-011
70-71:03C-012
70-71:03F-005
70-71:03F-045
70-71:03F-047
70-71:03F-054
70-71:03F-057
70-71:03F-065
70-71:03F-069
70-71:03F-070
70-71:04A-025
70-71:04A-038

Water consumption
70-71:03F-009

Water control
70-71:03F-042
70-71:03F-054
70-71:03F-065
70-71:03F-069
70-71:04A-018

Water cooling
70-71:02G-001
70-71:05B-055

Water costs
70-71:03C-004
70-71:06A-001
70-71:06A-004
70-71:06C-001
70-71:06C-003
70-71:06D-002
70-71:06D-003

Water demand
70-71:03F-012
70-71:06D-002

Water desalting
70-71:02D-020

Water disposal
70-71:05B-034
70-71:05C-005

Water distribution (applied)
70-71:03F-010
70-71:03F-012
70-71:03F-014

Water flow
70-71:02G-057
70-71:02G-058

Water law
70-71:03C-018

Water level fluctuations
70-71:03F-001
70-71:02F-011
70-71:02F-021
70-71:02F-022
70-71:02F-027
70-71:02G-029
70-71:05G-001

Water levels
70-71:02F-002
70-71:02F-003
70-71:02F-004
70-71:02F-010
70-71:02F-022
70-71:02F-027
70-71:02K-001
70-71:03F-021
70-71:04A-003
70-71:04B-003
70-71:07B-004

Water loss
70-71:02D-009
70-71:03D-010
70-71:02D-014
70-71:02I-001
70-71:03F-028
70-71:03F-054
70-71:03F-065
70-71:03F-069
70-71:04A-018
70-71:04A-027
70-71:08A-001

Water management
70-71:03F-060
70-71:04A-006

Water management (applied)
70-71:02G-043
70-71:03F-010
70-71:03F-012
70-71:05C-001

Water pollution
70-71:03C-009
70-71:03C-010
70-71:03C-011
70-71:03C-012
70-71:05B-023

Water pollution (Cont.)
70-71:05B-024
70-71:05B-030
70-71:05B-034
70-71:05B-040
70-71:05B-047
70-71:05B-049
70-71:05B-057
70-71:05C-014
70-71:05D-016
70-71:05G-020

Water pollution, affects
70-71:03C-017

Water pollution control
70-71:03C-005
70-71:03F-054
70-71:03F-065
70-71:03F-069
70-71:05A-007
70-71:05B-031
70-71:05B-033
70-71:05C-005
70-71:05D-010
70-71:05D-011
70-71:06B-002

Water pollution effects
70-71:05B-012
70-71:05C-006
70-71:05C-014
70-71:05G-015
70-71:05G-022

Water pollution sources
70-71:02E-014
70-71:02F-039
70-71:02G-083
70-71:02I-018
70-71:05A-001
70-71:05A-002
70-71:05A-003
70-71:05A-007
70-71:05B-002
70-71:05B-004
70-71:05B-005
70-71:05B-006
70-71:05B-007
70-71:05B-008
70-71:05B-010
70-71:05B-011
70-71:05B-014
70-71:05B-018
70-71:05B-019
70-71:05B-024
70-71:05B-026
70-71:05B-029
70-71:05B-030
70-71:05B-032
70-71:05B-040
70-71:05B-049
70-71:05B-058
70-71:05C-005

Water pollution sources (Cont.)
70-71:05C-014
70-71:05G-015

Water pollution treatment
70-71:05D-009

Water properties
70-71:02F-018

Water purification
70-71:02F-002
70-71:05F-001
70-71:05F-002

Water quality
70-71:01B-002
70-71:01B-003
70-71:01B-005
70-71:02A-004
70-71:02D-009
70-71:02E-003
70-71:02F-060
70-71:02G-011
70-71:02H-001
70-71:02K-001
70-71:02K-002
70-71:02K-004
70-71:02K-045
70-71:03C-003
70-71:03C-005
70-71:03C-006
70-71:05A-001
70-71:05A-005
70-71:05A-007
70-71:05B-002
70-71:05B-003
70-71:05B-011
70-71:05B-014
70-71:05B-016
70-71:05B-024
70-71:05B-029
70-71:05C-001
70-71:05C-002
70-71:05C-003
70-71:05C-004
70-71:05C-005
70-71:05C-015
70-71:05D-003
70-71:05F-003
70-71:05F-004
70-71:05G-020
70-71:05G-022
70-71:06B-002
70-71:06E-001

Water quality control
70-71:05B-016
70-71:05B-034
70-71:05B-048
70-71:05C-004
70-71:05C-015
70-71:05F-004
70-71:05G-014

Water quality control
  (Cont.)
    70-71:05G-015
    70-71:06B-002

Water quality standards
    70-71:05F-003

Water rates
    70-71:06C-001

Water requirement
    70-71:02G-043
    70-71:03F-001
    70-71:03F-012
    70-71:03F-036

Water resources
    70-71:02A-004
    70-71:02K-041
    70-71:04A-006
    70-71:04A-013
    70-71:05B-047
    70-71:06E-002

Water resource development
    70-71:03C-006
    70-71:05C-001
    70-71:05D-005
    70-71:06B-001

Water rights
    70-71:06E-002

Water reuse
    70-71:03F-054
    70-71:03F-065
    70-71:03F-069
    70-71:05D-003
    70-71:05D-004
    70-71:05D-005
    70-71:06E-001

Water sampling
    70-71:02F-035

Watershed
    70-71:02E-012
    70-71:05B-024
    70-71:05B-075

Watershed management
    70-71:04C-001
    70-71:05B-024

Water softening
    70-71:05C-003

Water sources
    70-71:02H-001
    70-71:03C-004
    70-71:03C-006
    70-71:05B-006

Water spreading
    70-71:02G-079
    70-71:05D-005

Water storage
    70-71:02F-027
    70-71:03F-005
    70-71:05D-004

Water supply
    70-71:03F-002
    70-71:04A-010
    70-71:06A-001
    70-71:06C-003
    70-71:06D-003

Water table
    70-71:02D-002
    70-71:02F-009
    70-71:02F-011
    70-71:02F-013
    70-71:02F-021
    70-71:02F-022
    70-71:02F-027
    70-71:02F-040
    70-71:02G-006
    70-71:02G-009
    70-71:03F-008
    70-71:04A-004
    70-71:04C-001
    70-71:04B-001

Water temperature
    70-71:02G-020
    70-71:05C-016

Water transfer
    70-71:06E-001

Water treatment
    70-71:05F-003

Water uptake
    70-71:02D-018

Water use
    70-71:02D-018

Water utilization
    70-71:02D-009
    70-71:02I-001
    70-71:02I-002
    70-71:02K-045
    70-71:03C-005
    70-71:03F-001
    70-71:03F-010
    70-71:03F-014
    70-71:04C-002
    70-71:06D-002

Water values
    70-71:06D-002

Water vapor
    70-71:02D-005

Water wells
    70-71:02F-021
    70-71:05B-005
    70-71:05B-006
    70-71:05B-007

Water yields
    70-71:02A-001
    70-71:02F-002
    70-71:02F-021
    70-71:02F-027
    70-71:02K-001
    70-71:04A-003
    70-71:04B-002

Weather
    70-71:02G-040
    70-71:03F-016

Weed control
    70-71:03F-037

Weeds
    70-71:03F-033

Well casings
    70-71:05G-022

Well regulations
    70-71:05B-006

Wells
    70-71:02F-029
    70-71:04B-003

Wettability
    70-71:02F-018

Wetting
    70-71:02F-018
    70-71:02F-026
    70-71:02G-005
    70-71:02G-023
    70-71:02G-031

Wheat
    70-71:02D-018
    70-71:02D-019
    70-71:02K-017
    70-71:03F-006
    70-71:03F-031
    70-71:05B-026

Wilting
    70-71:02I-004

Withdrawal
    70-71:02F-011
    70-71:02F-021
    70-71:04B-002

Wyoming
    70-71:03F-047

Yield
    70-71:02E-013
    70-71:02G-053
    70-71:02G-054
    70-71:02I-004
    70-71:02I-005
    70-71:03F-020
    70-71:03F-027
    70-71:03F-032
    70-71:03F-037

Zinc
    70-71:02I-017
    70-71:03F-026

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